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RADIO and ELECTRONICS

ELECTRICITY — COMMUNICATIONS — SERVICE — SOUND

In this Issue: A RESPONSE-COMPENSATED 6L6 AMPLIFIER

JANUARY 1, 1948

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RADIO and ELECTRONICS

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OUR COVER

OUR COVER this month gives a general view of the Response-compensated 6L6 Amplifier described in this issue.

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F.M. BROADCASTING IN NEW ZEALAND

There seems to be little doubt that the post-war attitude of the public towards developments in radio still causes an unwarranted reluctance to part with old, unsatisfactory receivers.

This attitude, as has been emphasized before in these pages, has been fostered by the popular press, through its avid reporting of any news dealing with radio techniques, and, in particular, news of television and frequency modulation broadcasting. It is quite understandable that radio should be news, by reason of its truly wonderful achievements during the war, but much of the publicity accorded it has been misleading to the layman, as much from what has been left unsaid, as from lack of technical understanding. Thus, as long as the public has the impression that, because television and F.M. are enjoying an increasingly wide vogue in America, it will not be long before their introduction into this country renders our present domestic equipment obsolescent, so long will our radio industry suffer.

The fact that Australia is shortly to have an experimental F.M. broadcast station brings the F.M. question even closer to home, and there is some justification for the layman to ask, "If in Australia, why not here?" There is no such justification for the radio industry to think along these lines; on the contrary, there is every reason for it to make a determined attempt to disabuse the public of some of its preconceived notions.

The facts about F.M. are these:—

(1) Like television, it operates of necessity on very high frequencies.

(2) Even if it were infinitely desirable from the listeners' point of view, adequate coverage even of large cities, with one or two possible exceptions, would be virtually unobtainable, since our country is among the most difficult in the world for the provision of a V.H.F. broadcast service.

(3) Even at this late stage, competent authorities are coming to the conclusion that F.M., as such, has little real advantage over A.M. under comparable conditions of frequency and bandwidth, and that the comparison between wide band F.M. and narrow band A.M. is not a real one at all.

(4) The success of F.M. in America is due to the great need in that country for more broadcast channels, which can no longer be provided on the "broadcast" band. In that country, F.M. does fulfil a need in that its superior reproduction cannot be realized on the broadcast band, owing to the limitation of channel width to plus and minus 5 kc/sec.

Here, however, the same considerations do not apply. The stage has not yet been reached where the quality of our broadcasts must be sacrificed to the provision of extra channels, nor is it in sight.

It is a fact that the quality of reproduction possible from our existing broadcasts is approached only by receivers in the highest price-brackets, and it is equally true that the market for such receivers is very limited. This being the case, what reason is there to suppose that combination F.M.–broadcast receivers would find a readier market than a high-priced all-wave receiver as we know it to-day? The combined F.M.–A.M. set would itself be more expensive than the best A.M. sets currently available, if the advantages of F.M. were to be realized.

In short, frequency modulated broadcasting would provide no advantages for the listening public that they cannot obtain for themselves by the simple expedient of demanding and buying high quality receivers for our existing services. For that reason alone it is important that the public be told that frequency modulation, like television, has no immediate prospect of application and a long-term prospect that need hardly be considered for many years to come.

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In rectangular metal cans . . .

Condensers of this type have made the name T.C.C. famous all over the world. The designs now offered are the result of many years' experience of manufacturing a device which requires great skill to avoid the pitfalls which, if neglected, will sooner or later cause trouble. T.C.C. Condensers are wound, to have the lowest possible inductance, with the best obtainable quality of linen rag tissue and aluminium foil. They are vacuum-impregnated and filled with petroleum jelly, the most generally satisfactory impregnant obtainable, and hermetically sealed into cans with, except in the small sizes, rolled and soldered seams. All this results in a condenser which will give an almost perpetual life under tropical conditions.

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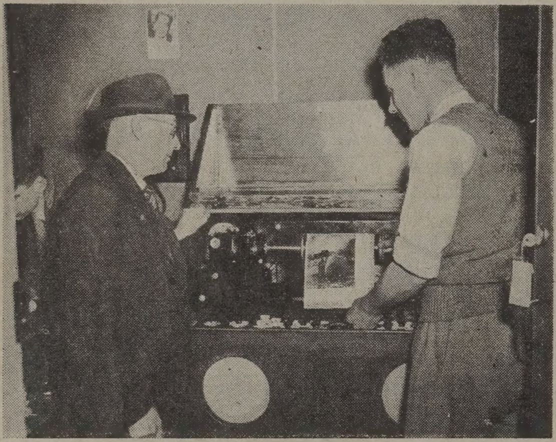
THE NEW RADIO PICTURE SERVICE

Telecommunications history was made on the 20th November when the radio picture service between New Zealand, Australia and the United Kingdom was opened by the Post and Telegraph Department.

The introduction of the system reflects great credit on the progressive aims of the Department for New Zealand is now able to keep pace with the rest of the world as far as news pictures are concerned—the pictures of the Royal Wedding amply illustrated this.



G. F. Burrow, Senior Operator of the Radio Photo Service, places on the drum the picture of Ballantyne's fire which was the first commercial photo to be transmitted to Australia. Frank Dyer, Director of Photo News, looks on.

The first commercial picture actually transmitted was a news photo of Ballantyne's fire. On the evening of the 19th November Mr. F. A. Marriott, Director of Photo News, Wellington, received a cable from Australia requesting pictures of the fire. He phoned the P. & T. Department and was told that the picture could be accepted. In view of this he placed a radio telephone call to Melbourne at 6.35 p.m. and at 6.55 was in contact with the required subscriber. At 10 a.m. the next morning the photo was transmitted and subsequently used in Australia.

The heart of the equipment is a crystal oscillator with a frequency of 108 kc/sec. from which is derived a stable frequency of 1800 C.P.S. This frequency is used to drive a synchronous motor which in turn is coupled by a gearbox to the picture drum shaft and lead screw. The picture to be sent is placed on the drum and locked into position. The drum shaft is hollow and in this cavity is the lead screw. The mechanism is such that when the motor is turning the drum revolves at 60 R.P.M. and at the same time moves along the shaft one inch per 100 turns while still at a constant speed.

At the back of the machine an exciter lamp is focussed to a spot of light 1 millimeter in diameter on the drum and the reflected light is picked up by two photo-electric cells—one above and the other below the exciter lamp. The effect of the rotation and traverse of the drum is to cause the spot of light to scan the picture in a spiral pattern of 100 lines per inch. The maximum size of the picture is 10 in. x 9 in. and takes about 16 minutes to transmit. The modulation voltage from black to white is a variation of frequency from 1600 C.P.S. to 2000 C.P.S.—black being at 1600 and white at 2000. It then follows that all shades of grey between black and white represent a frequency variation of 400 C.P.S. or a band width of 400 C.P.S. The modulation voltages are then used, in the normal way, to modulate a C.W. radio transmitter operating on a frequency of 15.5 mc/sec.

Perhaps one of the most important features of the equipment is the circuit used for synchronising at the receiving end for the receiver always synchronises with the transmitter. On the drum is a black metal bar about ⅜ in. wide which has the dual function of acting as a holding bar for the picture and a synchronising point. The bar is locked to the drum and as the bar passes the beam of light it causes a "black" pulse of 1600 C.P.S. to be transmitted.

This timing pulse is displayed at the receiving end in the form of a neon stroboscope which indicates whether the speed of the drum is fast or slow. A lever is fitted to the side of the gearbox which can alter the gear ratio and so adjust for perfect synchronisation.

For receiving, the same machine is used, the chief difference being that a "light valve" is brought into operation in conjunction with the exciter lamp. This forms a light ray modulator, which varies in intensity and is proportional to the amplitude of the modulated signal being received.

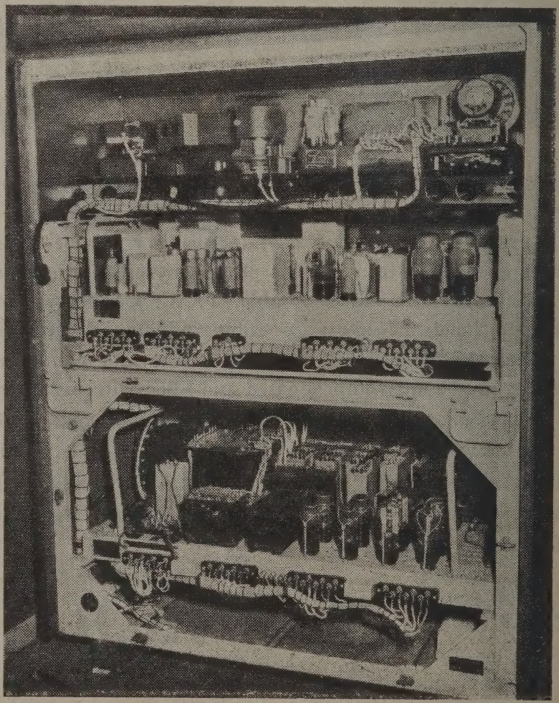


Illustration shows equipment necessary for producing timing and modulator voltages for modulating the C.W. transmitter.

A negative is coated with an extremely slow speed photographic sensitive emulsion (H and D 40). The varying light causes a corresponding change in the density of the negative, which of course is not apparent until the negative is developed. The print is taken off by normal photographic methods and the photograph is then ready for delivery to its final destination.

Obviously interference is the greatest factor affecting the clarity of the picture and to reduce this to a minimum band pass filters are used which allow frequencies within the required band width to be received. A limiter circuit is also used to keep the picture intensity constant over a wide variation of signal strength.

A microphone and Morse key are installed in the picture transmitting room and these are used by the operators to maintain communication with the radio photo service station with which it is working.

The procedure, once R.T. contact has been made, is to request "limit signals" to be sent by the transmitter. These signals consist of alternate "black" and "white" tones of 1600 and 2000 cycles respectively, thus allowing the operator to adjust his receiving set for the correct contrast of light values which correspond to the upper and lower limits of the modulated frequency. When this is done, the receiving station requests synchronising pulses to allow him to synchronise the drum with the transmitting station. This accomplished, the transmitter commences transmission of the picture.

These photos were received from London during tests before the service officially opened. At the left is an excellent example of radio picture reception. The other, received at a different and more unsatisfactory time of the day, shows the "noise" marks caused by interference.

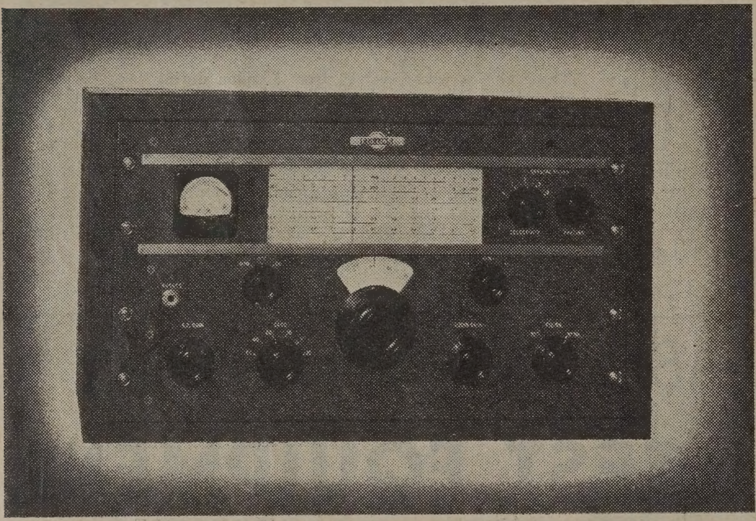
The Radio Photo Service is now an established and permanent part of New Zealand's communication systems and it is fitting here to refer to the excellent work done by Mr. Emmett, engineer in charge of the installation, and his team, for as we all know, their efforts have resulted in the reception and transmission of radio pictures of a quality which could not be surpassed.

A PERMEABILITY TUNED AMATEUR BAND RECEIVER

By L. W. COUILLARD, Design Engineer, Collins Radio Company

The Collins 75A Amateur Receiver represents a radical departure from conventional receiver design. While the basic ideas are not new, it is believed that Collins is the first manufacturer to apply them to a commercial receiver. These new features are: double conversion, permeability tuning, and shunt-band-switching. While there are several advantages to be gained by the use of each of these features, the inherent problems encountered restrict their application to rather special equipments such as the 75A. The receiver covers the amateur bands and gives a uniform linear frequency coverage of 1 megacycle on the lower bands and 2 megacycles on the 10-metre band.

EDITOR'S NOTE: While it is unlikely that the dollar situation will allow any of these receivers into the country, we feel that this radically "different" design will be of interest to many of our readers.

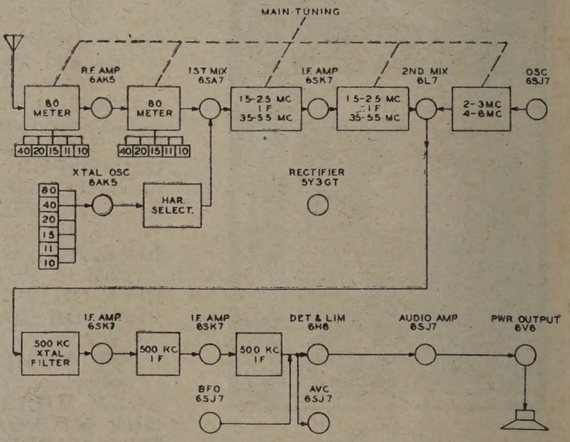


The 75A Amateur Receiver is one of several Collins units that have grown out of ideas developed for military application just before the war ended. The basic intent of the thinking behind this receiver was to achieve better than usual accuracy and stability in the reception of high and very high frequency radio signals. Quartz crystals had previously been regarded as the only means of achieving this end, but their application is limited because a different crystal is needed for each frequency. To obtain a continuously variable range of frequencies, a variable frequency oscillator is needed. To date these have not had the precision desired, a shortcoming which is specially troublesome at frequencies higher than 5 mc. Recently, however, there has been developed at Collins at new variable frequency oscillator (see "Collins Signal," October, 1946) with such greatly improved accuracy and stability that when used in the 2 to 3 megacycle range a definite frequency may be set and held within a few hundred cycles.

DOUBLE CONVERSION

The superior performance of this oscillator suggested the idea of building a superhet. receiver preceded by a crystal converter. By the use of this oscillator, a superheterodyne receiver can be built to cover the 2 to 3 megacycle range, and then precision cystals can be used to mix or beat with the high frequencies, resulting in heterodyne frequencies within the tuning range of the VFO tuned receiver. These two steps, (1) the use of crystals to convert the high frequencies to low frequencies, and (2) the use of an accurate, stable, permeability-tuned low-frequency oscillator, are combined in the 75A Receiver to make what is believed to be the most stable and accurate receiver currently being built.

To further explain the operation of the 75A, the frequency scheme and operation for one band will be elaborated upon. Incoming signals in the 20-metre band, which covers the range from 14 to 15 megacycles, are fed from the antenna coil through the R.F. stage (two slug-tuned circuits) and into the first mixer. The second harmonic output of an 8.25 mc. crystal is also fed in to the first mixer, resulting in an injection frequency at 16.5 mcs. The intermediate frequency output of the first mixer will then be somewhere between 1.5 and 2.5 mcs. We have thus overcome the first problem of converting the high frequencies to low frequencies, without introducing appreciable error. Next, these low frequencies are amplified by the first I.F. amplifier (also slug-tuned and ganged with the R.F. tuning slugs). The resulting signal is then fed to a second mixer. Here



75A BLOCK DIAGRAM

it is mixed with a 2 to 3 mcs. signal from the variable frequency oscillator resulting in a constant frequency (500 kcs.) output from the second mixer. This is the final I.F. frequency. The crystal filter, A.V.C., noise limiter, and final detector all operate at this fixed 500 kc. I.F. The important thing about

(Continued on page 55.)

A Response-Compensated 6L6 Amplifier

This amplifier has been designed in the first place for those who require the comparatively high output that can be provided by class A, 6L6's in push-pull, and secondly to fulfil the requirement for an amplifier incorporating independent control of amplification at high and low audio frequencies.

In spite of the rival claims of triodes and of other more modern tetrodes and pentodes, the 6L6 remains a very popular tube, although one seldom hears of its use these days in high-powered amplifiers, for which its companion type, the 8O7, is more suited.

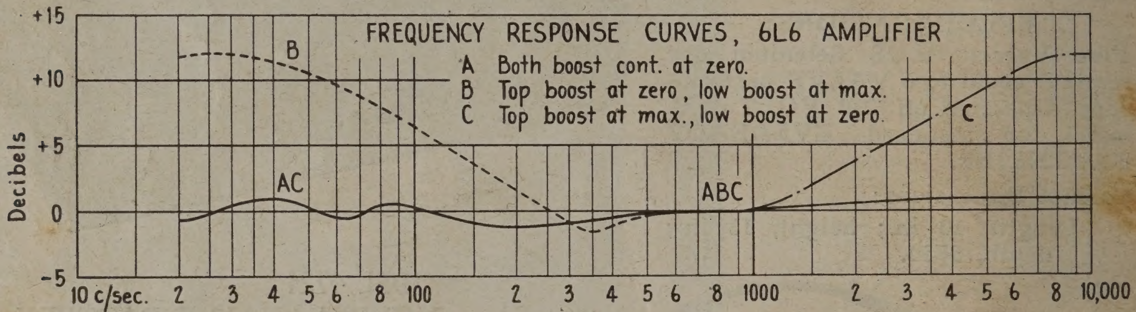
SPECIFICATIONS

This amplifier has therefore been designed for the high quality reproduction of gramophone records, without the use of any expensive components. Even the output transformer is a standard 20-watt P.A. type, whose performance is considerably improved by its incorporation in the amplifier chassis so that it has been possible to apply inverse feedback from the voice coil winding back to the cathode of the voltage amplifier stage.

Rated output (at the plates of the 6L6's) is 18.5 watts. A gain reduction factor of 3 is used with the feedback. The amplifier may be fully loaded by a signal of 0.35 volts peak, or 0.87 volts peak, according to whether or not R_{15} is shunted by a high-capacity electrolytic condenser. The frequency response on a loudspeaker load is flat within plus or minus 1 db. from 20 to 10,000 cycles per second, and over-all distortion is very low. The independent high and low boost controls have no effect on the apparent volume, since they leave the amplifier gain at middle frequencies entirely unchanged. No provision has been made for "cutting" the high and low frequencies, the frequency characteristic being "flat" when both boost controls are at zero. The setting of the main gain control has no effect upon the frequency response.

CIRCUIT FEATURES

It is customary when designing amplifiers to start at the loudspeaker end and work backwards towards the input. This procedure was followed here. The 6L6's are operated under self-biased conditions with 270 volts on plates and screens. R_{28}, the common bias resistor, has a value of 125 ohms, and in our case had to be made up from two 250-ohm 10-watt resistors in parallel. A point to note about the output stage is the use of grid stoppers, R_{27} and R_{29}. These are necessary as a precaution against parasitic oscillation, and should on no account be omitted. It is a safe bet that by far the majority of beam-tube amplifiers that do not perform properly, for no apparent reason, are afflicted with this "bug." Very often such an oscillation takes place only at high input levels, and results in amplifier overload long before rated output is obtained. Faults such as this cannot be spotted without an oscilloscope, so that the only safe thing is to include the grid stoppers. Even if they were not needed, they would have no adverse effect in any other way, so that they form a very cheap insurance premium against one of the most troublesome of amplifier faults.

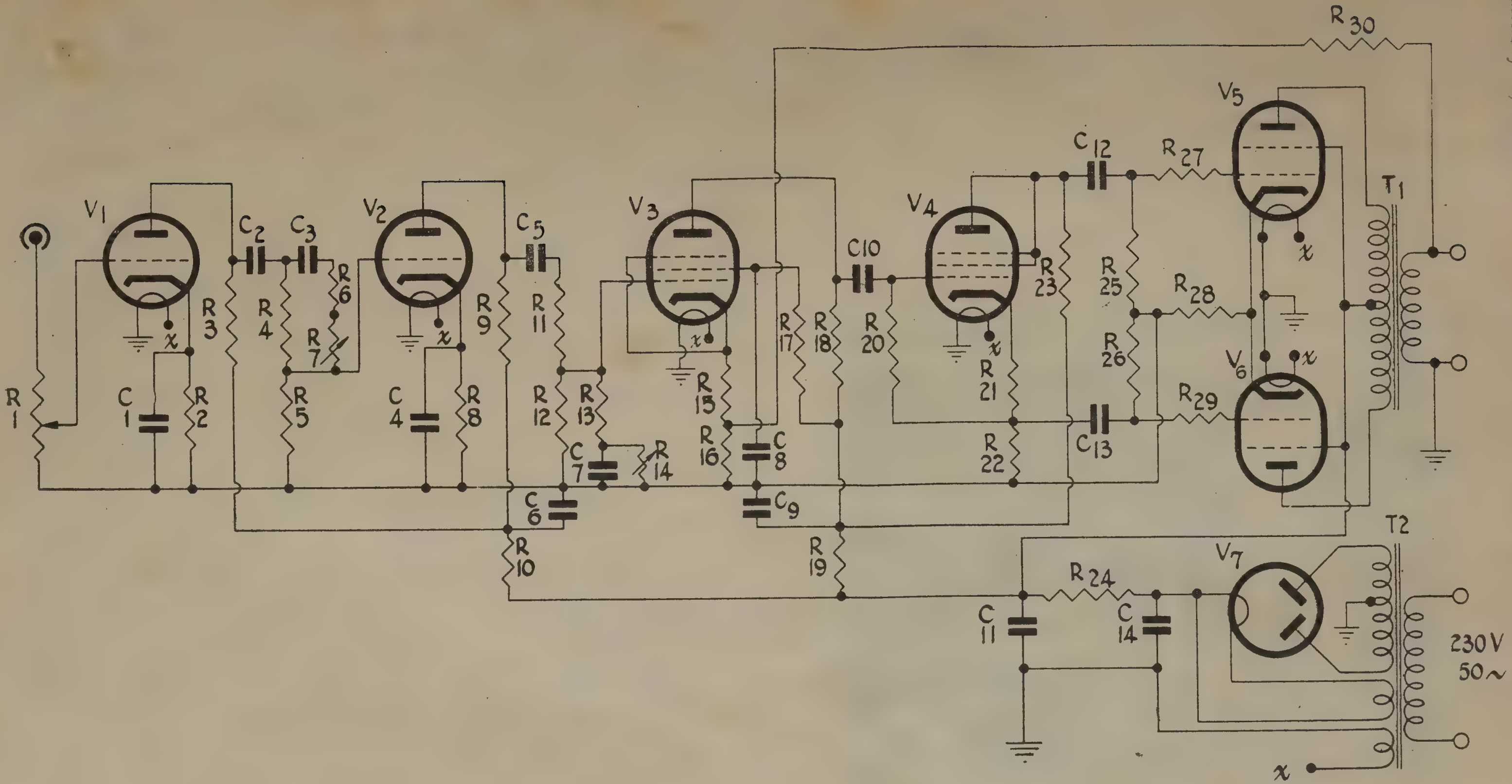


Response curves of the amplifier, taken on loud-speaker load.

The phase inverter is the well-known split-load type, which is even more satisfactory than usual in an amplifier of this type, because of the low driving voltage (only 20 volts peak per tube) required by the 6L6's. It uses a 6SJ7, strapped as a triode, because almost any tube will do in this circuit, and so as to make it the same type as the voltage amplifier, V_3, which is also a 6SJ7.

This tube is operated with a 100k. plate load, which normally gives it a gain of about 98 times. R_{15} is its normal cathode bias resistor of 1500 ohms. In the circuit this has been shown unbypassed, as doing so slightly improves its performance at full output. It has the disadvantage, however, of reducing the gain of V_3 by a factor of 2.5 times, but if the amplifier is used with a high-level pick-up, as it normally will be, this is no disadvantage, as the amplifier as a whole still requires only 0.85v. peak to drive it to full output.

The feedback is taken over the whole of the amplifier proper, from the voice coil to the cathode of V_3. This has the excellent effect of reducing the distortion which may arise in any part of the amplifier included in the feedback network, including the output transformer, which is by no means a high-fidelity one, nor is such performance claimed for it by the manufacturers. However, with feedback applied, the frequency response and distortion are good enough to be exceeded only by a really expensive output transformer.

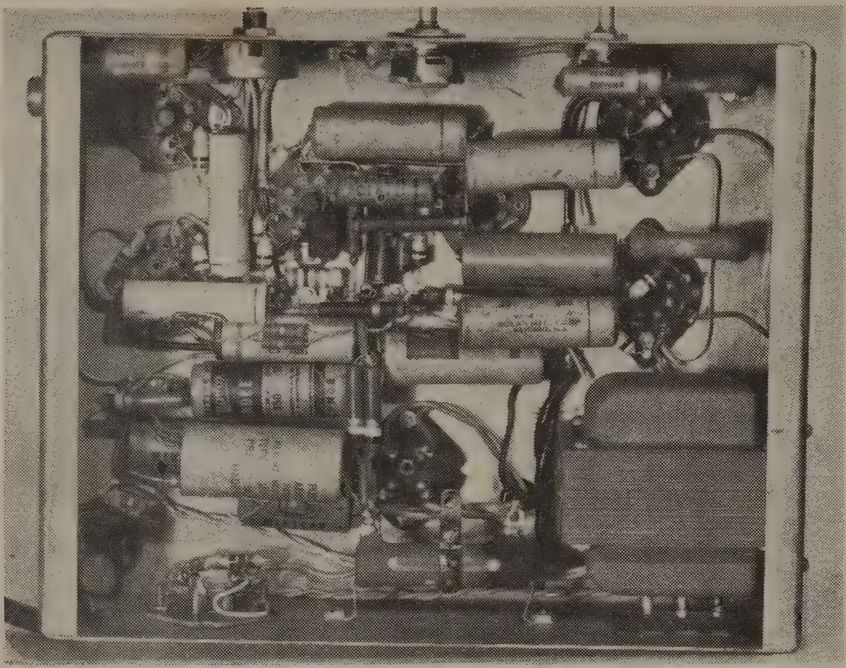


COMPONENT LIST

V_1, V_2 = 6C5.
V_3, V_4 = 6SJ7.
V_5, V_6 = 6L6-G.
V_7 = 5Z3.
R_1 = 0.5 meg. pot.
R_2, R_8 = 2.5k.
R_3, R_9, R_{18}, R_{22}, R_{23}, R_{27}, R_{29} = 100k.
R_4, R_{11}, R_{12}, R_{17}, R_{20}, R_{25}, R_{26} = 500k.
R_5, R_{13} = 50k.
R_6 = 25k.

R_7, R_{14} = 2 meg. pot.
R_{10} = 100k. 1 watt.
R_{15} = 1500 ohms.
R_{16} = 10 ohms.
R_{19} = 50k. 1 watt.
R_{21} = 1000 ohms.
R_{24} = 1000 ohms 20 watt.
R_{28} = 125 ohms 10 watt.
R_{30} = 250 ohms.
C_1, C_4 = 25 mfd. 25v. electro.

C_2, C_5 = 0.1 mfd. 600v.
C_3 = 250 mmfd.
C_6, C_9 = 16 mfd. 350v. electro.
C_7, C_{10} = 0.01 mfd. 600v.
C_8 = 0.5 mfd. 600v. paper.
C_{11} = 50 mfd. 350v. electro.
C_{12}, C_{13} = 0.25 mfd. 600v.
C_{14} = two 8 mfd. 450v. electros. in series, each shunted by 1 meg.
T_1 = Output transformer 5000 ohms p-p to voice coil.
T_2 = 400-0-400v. 150 ma.; 5v., 3 amp.; 6.3v., 4 amp.



change in volume when the boost controls are manipulated. If the top boost control only is in use, the total response will consist of the portions AC, ABC, and C of the curves. Similarly, when the low-boost only is in use, the high-frequency end of the response curve will remain unchanged, while the low-frequency end will be as at B. Of course, with intermediate settings of the controls, the boosted portions of the curve will slope less steeply.

These desirable characteristics are brought about by the use of V_1 and V_2, which act quite independently of each other and of the rest of the amplifier in providing high frequency and low frequency boost respectively. It will be seen from the circuit that these tubes, which are 6C5's, are quite normal resistance-coupled stages, except for the complex coupling networks in their plate circuits. First of all, let us take the case of V_1, the treble boosting stage. R_3 is a normal plate load resistor of 100k., and C_2 is a 0.1 mfd. coupling condenser. If we imagine C_3, R_6, and R_7 to be removed from the circuit, we are left with R_4 and R_5, which simply make a voltage divider or fixed gain control at the input of V_2. Now, the value of C_3 is only 10 mmfd., so that at low and middle frequencies its reactance is so high that it can be regarded as a virtual open circuit. Thus at middle and low frequencies the coupling circuit boils down to C_2, R_4, and R_5. These two resistors have values of 500k. and 50k. respectively, so that at middle and low frequencies one-eleventh of the output of V_1 is passed on to V_2. Since V_1 has a gain from grid to plate of 14 times, the effective gain of the V_1 circuit at middle and low frequencies is 14/11, or 1.27 times.

Now let us see what happens when R_7, the top boost control, is at minimum. At very high frequencies C_3 has a low reactance, and can be regarded for purposes of illustration as a short-circuit. We therefore have a new voltage divider comprising R_5 in series with R_4 and R_6 in parallel. Since R_6 has a value of 25k., we now have approximately two-thirds of the total output of V_1 applied to the grid of V_2, so that the gain of the V_1 circuit at high frequencies is $\frac{2}{3} \times 14$, or 9.33 times. Thus the high-frequency gain is 9.33/1.17, or 7.35 times the middle and low-frequency gain. This means that at the maximum boost setting of R_7 (i.e., with no resistance in) there should be a maximum of 17.3 db. However, examination of the response curves shows that in practice only 12 db. is realized at high frequencies.

IMPORTANT NOTE ON FEEDBACK CIRCUIT

It should be noted that the degree of feedback realized in practice depends not only on the values of R_{30} and R_{16}, but also upon the voice-coil impedance of the loudspeaker used with the amplifier. The constants shown have been worked out in theory and practice for a 15-ohm speaker, and so will not be correct for a speaker of any other voice-coil impedance. A table given later in this article shows what values of R_{30} should be used with speakers of voice-coil impedance other than this, and should be strictly followed. If it is desired to use a speaker of any other impedance, it is best to draw a curve from the table and to read off the required value of R_{30} from the curve.

THE HIGH AND LOW BOOST STAGES

The response curves on the first page of this article show clearly the effect of varying the settings of the boost controls. The full line shows the response with both controls at zero. The two very slight peaks at the low-frequency end of the scale show how effective is the bass-reflex or vented baffle which was used with the speaker and amplifier when the curves were taken. Without feedback, and without the reflex baffle, there would have been a very pronounced peak at about 70 cycles per second, the resonant frequency of the speaker which was used.

The portion marked ABC, on the curves remains identical, whatever the setting of the boost controls. Since the over-all volume is determined mostly by the frequency range between 300 and 1000 cycles per second, the curves show why there is no apparent

The main reason for this is that the above calculation assumes that the gain of V_1 is the same at very high audio frequencies as at low frequencies, but in practice this is not so, the reason being that at high frequencies the effective plate load for V_1 is reduced to 43,000 ohms, as against 83,000 ohms at low frequencies. This is enough to reduce the valve gain quite appreciably. However, since V_1 is a 6C5 with a low plate resistance of about 10,000 ohms, it can be seen that the frequency discriminating circuit will not produce any distortion due to too great reduction of the load impedance.

A point of interest is that the amount of boost obtainable with R_7 at minimum setting is dependent entirely on the relative values of R_4, R_5, and R_6. The value of C_3 has no effect on this, and altering its value affects only the point at which the boost commences. For instance, if C_3 were made smaller, the boost would start at a higher frequency, and if it were made larger the top boost would start at a lower frequency.

The action of R_7 in controlling the degree of boost can be seen when it is noted that R_7 has a maximum value of 2 megohms. When it is set at maximum it is almost equivalent to open-circuiting the $C_3R_6R_7$ branch, so that there remains only C_2, R_4, and R_5 in circuit, giving voltage division without frequency discrimination. A little thought will show, too, that as R_7 is increased in value the amplification at middle and low frequencies remains unchanged, so that there is no effect on the overall volume level, while all that happens is that the high end of the response curve becomes progressively flatter, until there is no boost at all.

The low-frequency boost control works in a similar manner to the circuit of V_1, except that in this case the voltage divider R_{11} R_{12} has its lower section shunted by the combination C_7 R_{13}. At middle and high frequencies C_7 has a low reactance, being a 0.01 mfd. condenser, and therefore acts as a short-circuit. Thus, at middle and high frequencies the circuit of V_2 has an overall gain of 1.27 times. However, at very low frequencies, C_7 can be regarded as almost an open circuit, with the result that R_{11} and R_{12} control the voltage division and increase the overall gain of the circuit. In this case the boost control R_{14} has to be connected in parallel with C_7 in order that the gain at middle and high frequencies may be unaffected when the control is operated.

POSITION OF THE RESPONSE-CONTROLLING STAGES

It will have been noticed that in this amplifier no attempt has been made to produce the bass and treble lift by modifying the voltage amplifier stage of the amplifier proper, namely, V_3. This has the great advantage that the amplifier proper is normal in all respects, and is not affected adversely by the varying load which is always imposed by a response-controlling network. Instead, the boosting function is concentrated in V_1 and V_2, which are both working at signal levels in the region of a volt or so. This ensures that overloading cannot occur in the boosting stages, under any circumstances. Also, the gain control of the whole amplifier is at the grid of V_1, which ensures that whatever degree of bass or treble boost is being used, the voltage stages of the amplifier cannot be overloaded before the output stage.

It has the added advantage that if the response-controlling stages are not wanted, the amplifier can be built with V_1 and V_2 omitted, in which case it is a straightforward high quality amplifier. Similarly, the part of the circuit up to the grid of V_3 can be incorporated at the front end of any good amplifier, and can be relied upon to give the same boost characteristics as with the present amplifier, without in any way prejudicing the performance of the main amplifier to which it is attached. This can be said of very few response-controlling stages, most of which provide undesired gain and introduce the possibility of amplifier overloading if care is not taken in their application. If the circuit of V_1 and V_2 is being applied to another amplifier, care should be taken to keep the gain control at the input of V_1 if overloading troubles are to be avoided.

OSCILLATION OF THE MAIN AMPLIFIER

We have already discussed the use of grid stoppers with the 6L6's in order to prevent oscillation of the output stage, but with this circuit there is a further possibility of oscillation of the amplifier as a whole. If a high-fidelity output transformer were used, its phase shift would be small enough for the possibility of oscillation to be fairly remote, but here we are not using such a transformer. As a result, it is possible that at some high frequency, outside the audio range, the phase shift in the output transformer may be sufficient to change the feedback from negative to positive, and for oscillation to result. This can be guarded against by connecting a small condenser, not greater than 100 mmfd., from the plate of V_3 to earth. This should be just large enough to stop the oscillation, if it occurs, but not any larger, so that it will not reduce the high-frequency response of the amplifier.

If an oscilloscope is available, the easiest check for the presence of oscillation is to examine the output wave-form of the amplifier with it. Oscillation will be readily seen as a high-amplitude high-frequency deflection, which bears little or no relation to the amplitude of the input signal. If it occurs only at some signal levels, it can be seen by feeding a signal into the amplifier and working the gain control from zero to full output. If it is happening all the time, it will show as a high-frequency output on the 'scope, even when no input is applied to the amplifier. If a 'scope is not available, such oscillation can be suspected if the reproduction does not sound quite "clear" or if unaccountable distortion takes place at medium or low signal levels.

POWER SUPPLY

It will be noted that this amplifier has been arranged for use with a permanent magnet speaker, and that no smoothing choke has been used. R_{24} is a 1000-ohm 20-watt wire-wound resistor, which, in conjunction with the 16 mfd. electrolytic condensers C_{11} and C_{14}, gives quite adequate smoothing for the plates and screens of the output stage. The filters $R_{19}C_9$ and $R_{10}C_8$, as well as providing adequate decoupling for the early stages, and therefore preventing any possibility of low frequency instability or motor-boating, are absolutely necessary in order to provide a smooth enough H.T. voltage for V_1,

V_2, and V_3. Constructors who are not used to seeing smoothing chokes dispensed with need have no fear, however, that the amplifier is subject to hum, for in practice the hum level is exceedingly low—in fact, better than is normally realized with an electro-magnetic speaker when the field coil is used as the second choke in a two-stage filter. C_{14} is made up from two 450-volt 8 mfd. condensers in series, but C_{11} can be of 450v. working rating.

CONNECTING THE FEEDBACK

The feedback can be connected the wrong way round, with the circuit used, since the correct side of the voice-coil winding must be found. This can be done quite simply by running the amplifier at low level without R_{30} connected to the voice-coil and therefore without feedback. One side of the voice-coil winding is temporarily earthed, and R_{30} is touched on to the other side. If the volume decreases, the polarity is correct, and permanent connections can be made. If the volume level increases when R_{30} is connected, the feedback is positive, and the connection must be made to the other side of the winding. The indication is quite positive, and the check will be easily made.

CONSTRUCTION

The front-cover photograph gives a good idea of the lay-out of the amplifier, if used in conjunction with the under-chassis picture. The input socket is on the side of the chassis, adjacent to V_1, which is the valve shown in the front left-hand corner of the top view. The tube directly behind this is V_2. The only point of any importance about the lay-out is the way in which the boost controls are wired. This can be seen from the under-chassis photograph.

The control in the centre of the chassis front is R_7, and the one to the right of it is R_{14}. Wired right at the controls can be seen R_6 and C_3, and R_{13} and C_7. The leads from C_2 to C_3 and from R_7 to the grid of V_2 are unshielded and run close to the chassis and with right-angled bends so as to be as far away as possible from the socket of V_3. The leads from the junction of R_{11} and R_{12} to R_{13} is run in shielded wire, as in this case it can have very little effect on the performance of the stage, and because the distance to R_{14} is much greater. With the wiring lay-out shown in the photograph, everything worked perfectly, with no trace of instability or undesired coupling between circuits. For those who wish to use a similar chassis lay-out it may be mentioned that the prototype illustrated here was built on a chassis 10½ in. x 8½ in. x 3 in. This is just deep enough to accommodate the output transformer, and although there is no waste space on the chassis, there is no need for the parts to be overcrowded if suitable tie-points are provided by means of small

(Continued on page 56.)

THE RADEL PORTABLE FIVE

In last month's issue we published the design of a four-tube portable receiver which was very suitable for local station listening, and which was not of extremely compact construction. The present set is designed for those who need a portable with somewhat more sensitivity than that of the "Portable Four" and at the same time has been made considerably smaller physically, for those who prefer a more compact set.

CIRCUIT.

The circuit of the receiver is very similar to that of the four-valve model, and indeed, is identical in many respects. The extra sensitivity has been gained by the use of an R.F. stage, V_5, whose grid circuit is the tuned loop, and which has an untuned coupling from its plate to the grid of V_1, the oscillator-mixer.

This system does not provide quite as much sensitivity as if tuned coupling had been used between the R.F. and mixer stages, but gives enough to be very useful, without the necessity of using a three-gang midget condenser. An alternative arrangement would have been the use of V_5 as an extra stage of I.F. amplification. This would provide more actual gain, but would definitely be inferior to the present scheme from the standpoint of signal-to-noise ratio. For this reason the distant-station performance would not be as good as it is with the R.F. stage, in spite of the lower overall gain.

A.V.C.

Automatic volume control has been applied to the R.F., mixer, and I.F. stages, and results in a very good A.V.C. characteristic. The mixer grid return, R_{11}, is taken not to chassis but to the A.V.C. line, and provides decoupling as well as a D.C. path.

V_5 FILAMENT CIRCUIT

In the circuit diagram one side of the filament of V_5 has been shown earthed, while the other side has been shown unconnected. This should be joined to the A + lead, the shortest connection being direct to the A + filament pin on the socket of V_1.

CHASSIS LAYOUT

The chassis layout can be seen by reference to the working drawing for the chassis, and to the photograph showing the completed set installed in its cabinet.

The chassis has no sides, but only ¼ in. flanges for strengthening purposes. This is quite adequate, since the dimensions are so small that very great rigidity is obtained even with 20 or 22 gauge steel for the chassis material. The two dotted squares marked "×" on the diagram are **not** cut-outs, but serve merely to show the positions of the midget I.F. transformers. The valve nearest the front of the chassis is for the R.F. stage, V_5, while the one behind it is for V_1, the oscillator-mixer. Along the back of the chassis from left to right are V_2, V_3 and V_4. The $^7/_{16}$ in. hole in the front of the chassis is for the on/off switch, while the other is for the volume control. The ⅛ in. holes at the left-hand side of the chassis, to the right of the V_1 and V_5 valve socket holes, are for the stator leads to the gang condenser. The latter is mounted so that its shaft is directly above the $^7/_{16}$ in. hole for the on/off switch, and exactly $1^{15}/_{16}$ in. above it. A small panel must be made for mounting the gang, as both the available midget types mount by means of screws through the front plate. The shape of the mounting panel is immaterial, as long as it is large enough to accommodate the screws to mount the condenser, and also to be screwed with two nuts and bolts to the front of the chassis. The space on the chassis in front of the V_3 and V_4 socket holes is for mounting the output transformer, which can be seen quite clearly in the photograph.

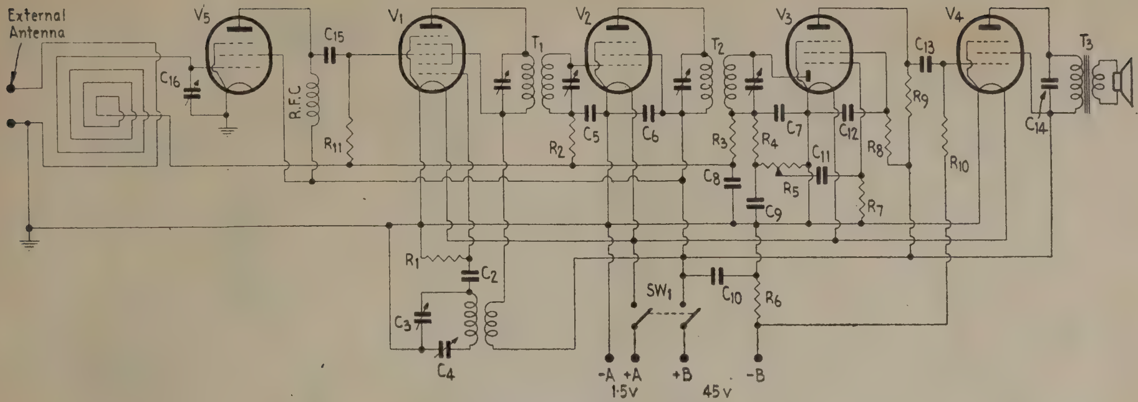
Back view of the receiver showing the physical layout of the chassis, speaker and batteries. Although the set is quite small, there is plenty of space available.

In this receiver the loop is screwed to the back of the cabinet, as shown in the photograph. Of course any desired cabinet design may be used, but the inside-dimension diagram shown is probably as good a layout as can be devised for the use of a 3 in. speaker. These are in fairly short supply at the moment, but it is understood that reasonable quantities will be available in the near future, both from import and from local manufacture.

CABINET LAYOUT

The cabinet with its battery compartments can be laid out in any convenient manner, not necessarily adhering to the layout used in the original model.

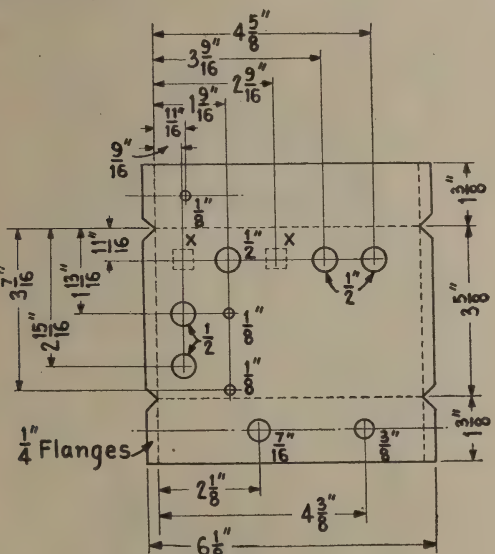
All dimensions on the cabinet diagram are inside measurements, and so do not allow for the thickness of the material used. This is the easiest way of specifying the cabinet without fixing the thickness of the material, which is not important. In the interests of small size and lightness wood no thicker than ¼ in. is recommended. There is room, if necessary, for quite large strengthening blocks in the two top corners and in the corner between the left-hand

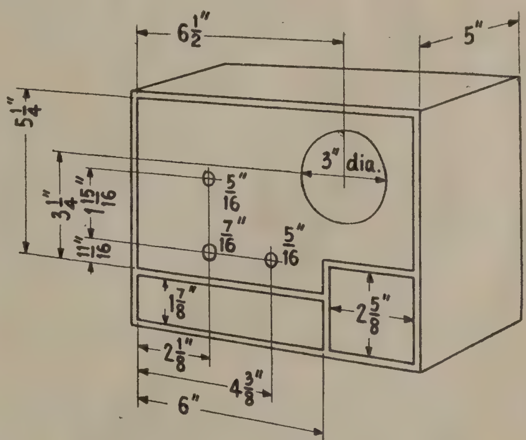


COMPONENT LIST

C_3, C_{16} = midget two-gang condenser.
C_2 = 50 mmfd. mica.
C_4 = 600 mmfd. padder.
C_5, C_6, C_8, C_{12} = 0.02 mfd. paper.
C_7, C_9, C_{15} = mmfd. mica.
C_{10} = 8 mfd. 50v. electro.
C_{11}, C_{14} = 0.002 mfd paper. C_{13} = 0.0005 mfd.
R_1, R_2 = 100k.
R_3, R_{10} = 2 megs
R_4 = 50k
R_5 = 1 meg. pot.
R_6 = 500 ohms.
R_7 = 10 megs.
R_8 = 3 megs.
R_9, R_{11} = 1 meg.
T_1, T_2 = midget 465 kc/sec. I.F. transformers.
T_3 = output transformer, 8000 ohms to V.C.
Sw_1 = D.P.S.T. on/off.
V_1 = 1R5; V_2, V_5 = 1T4; V_3 = 1S5; V_4 = 1S4.
"A" Battery = type No. 742.
"B" Battery = type No. 482.

Note.—If desired, a 67.5v. battery type may be used instead of type 482 for the "B," and will give higher output power. The only change necessary would be to increase the rating of C_{10} to a value higher than 67.5 volts.





At Left: Working drawing of chassis.
Above: Skeleton drawing showing layout of partitions in the cabinet, and the placement of the necessary holes in the front. All measurements are INSIDE dimensions.

side (in the photograph) and the top of the "A" battery compartment.

ALIGNMENT

The alignment of this set is exactly similar to that of the "Portable Four," since the coupling between R.F. and mixer tubes is untuned. For those who may not have read the article describing the previous set, it may be as well to detail the lining-up procedure.

First of all the I.F. stage should be peaked up. The midget I.F. transformers used in the prototype were permeability tuned ones with the "slugs" operated by threaded rods, one at each end of the transformer. Since these are imported and make no claim to be adjusted to any particular frequency, they will have to be properly lined up from scratch. If no signal generator is available they can still be lined up if one has a receiver which has an intermediate frequency of 465 kc/sec. All that needs to

be done is to take a lead via a small condenser from the set which is already aligned to 465 kc/sec. to the grid of the I.F. stage on the portable. This condenser needs to be very small and should consist of two pieces of insulated wire twisted together for half an inch or so. Also the chassis of the portable should **not** be connected to the set chassis, for fear of accidentally removing the bias in the latter. Next a strong signal at 465 kc/sec. is provided by tuning the set to a local station. The portable now has its trimmers peaked up for loudest signal from its own speaker, the volume control of the other set being turned right off. As the I.F. stage is brought into line it may be necessary to reduce the input from the other set by using only a very short piece of wire for an aerial, for the very strong signal will be required only when the portable's tuning is a long way out, and may overload the latter as it is brought nearer to correct tuning.

The best points at which to align the trimmers and padder after the I.F. has been aligned, are 1450 and 600 kc/sec. respectively.

Again, if a signal generator is not available, the existing set with the 465 kc/sec. I.F. can be used, by taking advantage of the fact that the portable will be able to pick up radiation from the set's oscillator. To do this, both sets should be turned on, and the portable's aerial loop placed quite close to the other set. The latter is then tuned to a dial reading of 985 kc/sec. This puts its oscillator on a frequency of 1450 kc/sec., and the signal from it should be heard when the portable is tuned near the high frequency end of the band. Of course the oscillator will be unmodulated, except possibly for some slight hum, but a temporary volume indicator may be made by connecting a milliammeter on a 0-10 volt scale in the B + lead of the portable. Maximum volume with this scheme is shown by **minimum** meter current, since the A.V.C. action reduces the total drain from the battery quite noticeably.

When the signal has been picked up, the aerial trimmer is tuned for maximum output from the portable. If no maximum position can be found, the oscillator trimmer of the portable should be shifted and the signal tuned in again. Then the aerial trimmer is tried again for a maximum volume setting, and, if found, it is adjusted to this position.

The next adjustment that has to be made is to the padder condenser, C_4. The other set cannot be used to provide a signal at 600 kc/sec., but the exact frequency of adjustment of the latter is not very critical.

If there is a good deal of external noise the padder may be adjusted on it. To do this, the gang condenser is turned to a position about 30 degrees from the fully closed position, and the padder is adjusted for maximum output in the speaker.

If the locality is not noisy enough for this to be done, a vacuum cleaner or other small motor can provide all the noise necessary for lining up the padder.

Of course the expedients we have described above are not to be compared with the proper method of using a signal generator, but they will work well enough to put the set quite close to a properly aligned condition, so that the operation can be checked. It is always a good plan to take the completed set to a serviceman for exact alignment after one has made sure that it is working correctly.

(Continued on page 56.)

THE NEW ZEALAND ELECTRONICS INSTITUTE

INSTITUTE NEWS

With the close of the year 1947, the New Zealand Electronics Institute has held its fifty-sixth technical meeting, an average of three meetings a month since its inception. Some 200 applicants for membership were considered and plans were completed for the making of application for incorporation of the Institute. The following is a brief summary of the subject matters of the various meetings held since June.

At Auckland, members were addressed by Mr. Ian C. Hansen on the subject of "Transformer-coupled Amplifiers," by Mr. L. O. Hunter on "The Installation of Loudspeakers in the Walls of a Room," and by Mr. B. G. Willis on the subject of "Technical Information and How to Find it."

Wellington members attended an address given by Mr. B. T. Claydon dealing with modern X-ray equipment, whilst at Christchurch, Flying Officer R. A. Danrell lectured on "Time Bases and Time Base Generators." Dunedin members were fortunate in holding two meetings, one addressed by Mr. G. E. Roth on some unusual methods of generation of high voltages and the other by Mr. J. Miller on the subject of "Motors and Signalling."

In July, at Auckland, Mr. G. Alcock spoke to members on the subject of "R.F. Heating Equipment," and Mr. Ian C. Rowe addressed Wellington members on the uses of modern mixer tubes. Christchurch members had the pleasure of hearing Mr. B. T. Withers on the subject of "Grid-controlled Rectifiers," whilst Dunedin members held a film evening, showing films entitled "Window and Electronics at Work."

In August, Mr. Ian Hansen was again the speaker at the Auckland meeting, his subject being "A Weak Link in Sound-reproducing Systems." At Wellington Mr. S. M. Reynolds spoke to members on "The New Zealand Post Office Long-distance Telephone Circuits." Mr. G. Gardiner addressed Christchurch members on the subject of "Ionospheric Forecasting," whilst Dunedin held a "Questions and Answers" evening.

In September, Auckland members had an address on "Modern Railway Signalling" by Mr. I. D. Stevenson. Wellington members paid a visit to the Dominion Physical Laboratory at Gracefield, whilst Christchurch members visited the Electrical and Wireless School at Wigram. At the Dunedin meeting, Mr. J. F. McCahan was the speaker, taking as his subject "Cosmic Radiation." The first Institute examination was held in three of the main cities during this month.

In October whilst Dr. T. R. Marshall addressed Auckland members on the uses of X-rays in medicine, Mr. J. H. Inder spoke at the Wellington meeting on the subject of the theoretical and practical applications of inverse feedback in amplifiers. At Dunedin, Messrs. E. S. Anderson and J. Stone selected separate aspects of the subject of loudspeakers about which to speak to members.

Technical meetings were concluded in November. Wellington members paying a visit to the Titahi Bay transmitting station, Dunedin members visiting the X-ray department of the Dunedin Hospital, while at Christchurch Mr. G. E. Roth dealt with some aspects of high-voltage generation in the kilovolt and megavolt ranges.

The final Council meeting for 1947 was held in Wellington on 11th November. Members expressed considerable satisfaction at the progress of the Institute, and advised that it is intended to apply for incorporation of the Institute early in the new year. Before applying for incorporation, the Council will submit to members for early confirmation certain amendments to the constitution which experience has shown to be highly desirable.

The Council acknowledges with thanks the valuable assistance rendered by "Radio and Electronics" in providing publication of Institute news. To the proprietors of the journal and to all members of the Institute, Council members extend their best wishes for a successful new year.

The PHILIPS Experimenter

Inserted by Philips Electrical Industries of New Zealand.

No. 3: A HIGH-PERFORMANCE T.R.F. RECEIVER USING EF50's

In these days, the recommendation of a T.R.F. receiver with a regenerative detector will probably need some justification, in view of the almost universal popularity of the superhet., but such justification is easy to find.

In the first place, a T.R.F. receiver can be built far more quickly and much more cheaply than any good superhet. Secondly (and this is most important), it needs far less in the way of tricky coil adjustment than does the super, and has no tracking troubles worthy of the name, even when a fairly wide waveband is to be covered by each set of coils. Thirdly, since the appearance of high mutual-conductance pentodes of the type developed for television receivers, a T.R.F. can be built having much more gain than could ever be realized with conventional tubes, and, in fact, an overall performance which almost approaches that from a quite good superhet., and which certainly exceeds that of a poorly-designed one.

THE EF50

The valve which forms the basis of the receiver described in this article is the Philips Miniwatt EF50, which was very widely used in British service equipment during the war, and which is designed to give useful amplification up to frequencies as high as 150 mc/sec. Although the receiver is not designed to reach frequencies as high as this, it is clear that the performance of the EF50 at 30 mc/sec. and even higher will far exceed that of standard valves at these frequencies. This refers not only to its use as a tuned R.F. stage, but also to the triode-connected EF50 used as the regenerative detector in the present set. The highest range of coils built took the frequency to 40 mc/sec., where regeneration was as smooth and as easily obtained as anywhere else in the frenquency range.

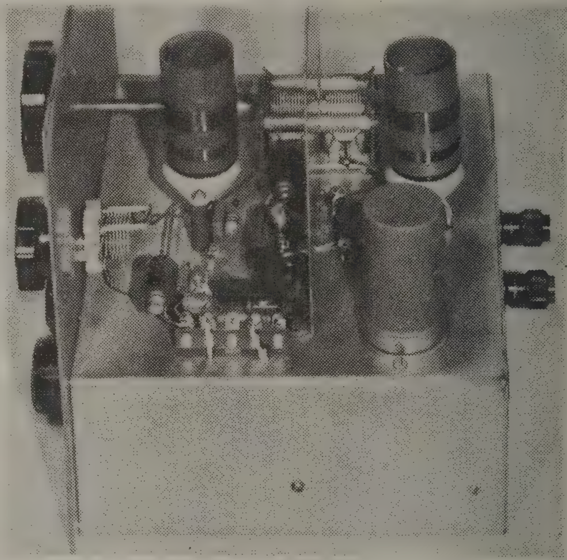
The EF50 is of all-glass construction, and anticipated the present-day miniature tubes in using the button-base type of construction in which the element supports come straight through the glass to act as connecting pins. The lead lengths are thereby made very short, with consequent reduction in inductance and improvement in high-frequency performance. The tube is enclosed in a thin aluminium shield, and has a metal locating pin which also helps to shield the input from the output side of the circuit. It is an easy matter to place a shield partition right across the socket so that very complete isolation of the circuits is obtained and stable performance is assured. As well as its high mutual conductance and low input and output loading, the EF50 has an exceptionally low equivalent noise resistance, so that there is a very real advantage in its superior performance on weak signals.

THE CIRCUIT

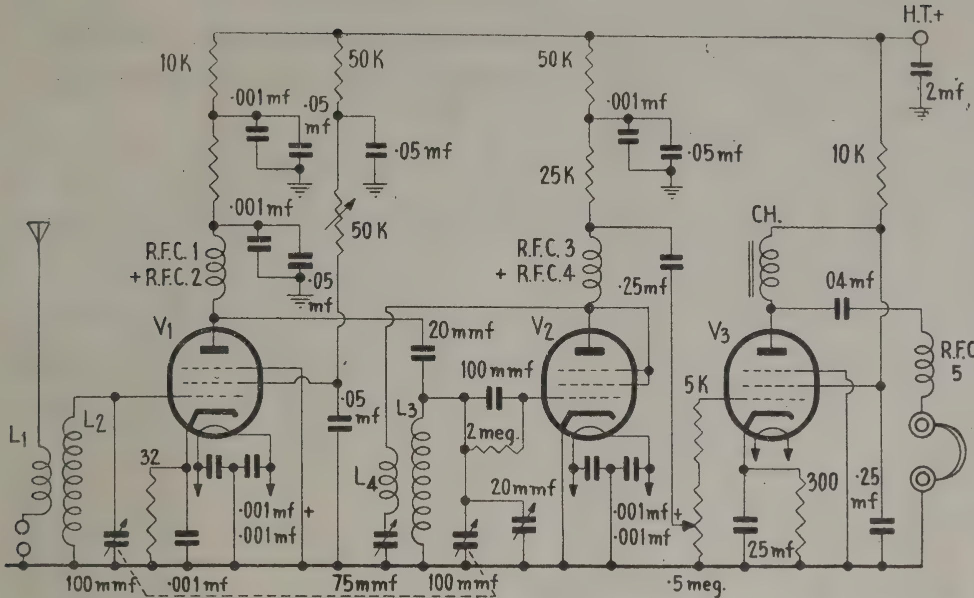
While it is not proposed to go into the circuit in great detail, there are a number of points about it that require special mention if the set is to be better than average in stability and ease of handling. These qualities were outstanding in the prototype model, and if the circuit and construction are closely followed, the present set will be found one of the most effective T.R.F. designs yet published.

The first point of note is the use of choke-capacity coupling from R.F. amplifier plate to detector grid. This circuit is not very often encountered, but there are three very good reasons for using it. In the first place, it greatly simplifies the ganging of the R.F. and detector tuning controls, by allowing the circuit constants in each case to be made identical. Secondly, the added complication of a primary winding on the detector coil provides no extra gain; thirdly, it simplifies the detector coil design very much. There are, however, precautions which must be taken if this system is to be satisfactory. Most important is the use of a really effective R.F. choke (RFC_1 + RFC_2). A single choke to be effective from 80 to 10 metres is a difficult one to design, and, though commercial chokes are stated to cover this band without any "holes," it is best not to rely too much on this, and to use two chokes in series. Thus, (RFC_1 + RFC_2) and (RFC_3 + RFC_4) each consist of standard 2.5 mH. chokes in series with a home-made high-frequency choke. The latter consists of 200 turns of fine wire (36-gauge or so) jumble-wound on a 1-watt resistor and fixed in place with wax.

Another important point is the use of a very small coupling condenser (20 mmfd. only) to the



Top view of the receiver. The R.F. socket is on the near side of the gang condenser, with the shield partition directly across its centre. The detector socket is directly behind the small band-spread condenser when view from the front panel. It can be seen to the right of the R.F. choke in the foreground.



Circuit, complete with all values. H.T.+ can have any value between 250 and 300 volts, but the higher voltage is to be preferred. The audio choke CH can be the primary of any small audio transformer.

detector grid circuit. This helps both to increase the selectivity and to keep the detector grid capacitative loading approximately the same as that of the R.F. stage grid, thereby helping to ensure accurate ganging.

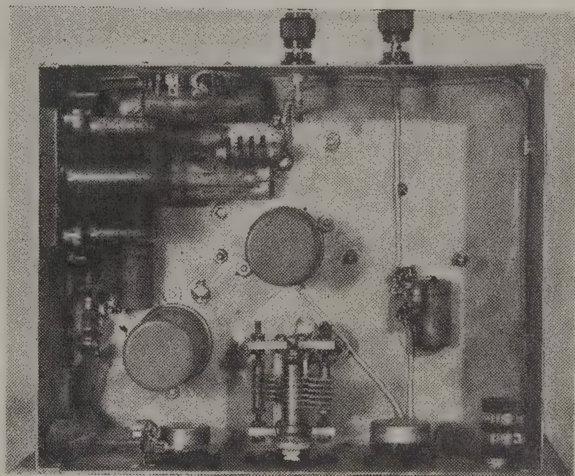
Also important is the comprehensive decoupling in the R.F. and detector plate circuits. Adequate decoupling is important in any receiver, but where high-gain tubes such as the EF50 are used it is even more important still if stability and high gain are to be realized in practice. Note the use of double bypass condensers of widely different values. This ensures that the decoupling does not become ineffective at high frequencies because of the inductance of the larger paper condenser. Similarly, the R.F. and detector heaters are centre-tapped at the power supply and each terminal is bypassed at the socket as a precaution against modulation hum.

The regeneration system used here is an old one which has the virtues of smoothness and quietness. These qualities are all that can be asked of a regeneration system, so that there is no necessity for any of the fancier schemes.

Choke-capacity coupling is used to the headphones from the audio stage in order to remove the D.C. from the latter. Note also the R.F. choke in the phone leads, RFC_5. This is an ordinary 2.5 mH. choke, and serves to eliminate body-capacity with the headphones.

CONSTRUCTION AND OPERATION

A set of this nature can be constructed with any reasonable lay-out of parts, but a very good though unconventional arrangement was chosen for the prototype. The R.F. and detector tubes are mounted under the chassis, while the coils and their sockets are mounted on distance-pieces above it. This enables very short wiring to be made in all the R.F. portion of the receiver, and the positioning shown in the photograph allows corresponding leads in R.F. and detector circuits to be made the same length. Thus the stray capacities in each circuit are made very



Underneath view. The R.F. tube is in the centre of the chassis, and the other that can be seen is the detector. At the left towards the rear is the audio transformer used as the audio choke, and concealed underneath this is the audio tube socket.

closely equal, with the result that identical grid windings are used, and very good ganging is obtained without the use of trimmers. A point to note is the way in which the shield partition is mounted across the R.F. stage socket, with the R.F. section of the gang condenser, the R.F. coil, and the grid pin of the R.F. tube all on the rear side of the shield. The audio stage is also mounted on this side of the shield partition the right way up, and far enough away from the R.F. coil to have no effect on its inductance. The audio transformer whose primary is used as a choke is mounted under the chassis and can be seen in the under-chassis photograph.

All the detector components except the regeneration condenser are mounted on top of the chassis, small terminal strips being used as tie-points where necessary. The three controls seen along the bottom of the under-chassis photograph are audio gain, regeneration, and R.F. gain respectively. The lead to the phone jack can be seen running round the side and back of the chassis in shielded wire. This is necessary to prevent R.F. pick-up.

There is nothing difficult or tricky about the operation of this set. If it is carefully constructed, the ganging will be excellent, and the smoothness of regeneration all that can be desired. If the regeneration control is turned rapidly enough, the detector will go into oscillation with a "plop," but this is NOT due to unstable regeneration, in which the sensitive "edge" cannot be attained, however carefully the control is adjusted. The very small bandspread condenser connected in the detector circuit has a low enough value for it to be used independently of the gang condenser over most of its range with very little effect on the gain of the R.F. stage. If desired, however, a similar condenser could be used as an R.F. trimmer to ensure perfect R.F. tuning on all settings of the bandspread condenser.

COILS

Data are given here for two sets of coils, one to suit a gang of 150 mmfd. per section, and the other for a 100 mmfd. gang. Either specification may be used according to taste, but our preference is for the 100 mmfd. gang, which gives a somewhat less cramped frequency scale.

Table 1: Coil Data, 150 mmfd. Gang:

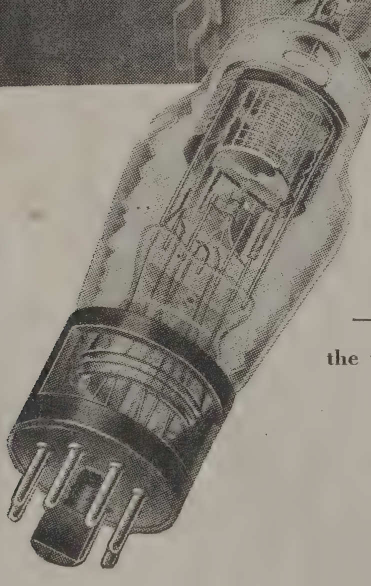
Frequency Coverage	Turns L_1	L_2	L_3	L_4	Wire S.W.G. en.
15-32 mc/sec.	$2\frac{1}{2}$	3	3	2	18
7-15 mc/sec.	3	6	6	3	18
3-8 mc/sec	10	20	20	10	30
1.6-3 mc/sec.	10	45	45	10	30

Table II: Coil Data, 100 mmfd. Gang:

Frequency Coverage	Turns L_1	L_2	L_3	L_4	Wire S.W.G. en.
20.8-40 mc/sec.	3	3	3	3	18
11.25-21.8 mc/sec.	$3\frac{1}{2}$	6	6	$3\frac{1}{2}$	18
6.1-11.3 mc/sec.	6	12	12	6	30
3.4-6.4 mc/sec.	9	20	20	9	30

Note.—All coils on $1\frac{1}{4}$ in. formers, $\frac{3}{8}$ in. between windings. All close-wound except two H.F. ranges of Table II, where L_2 and L_3 are wound 16 turns per inch. L_1 and L_4 close-wound in all cases.

Next month's "Experimenter" will present concise data on some of the outstanding new Philips valves specially designed for high and ultra-high frequency receivers and transmitters.



SERVICING VIBRATOR PACKS

Although with the progressive expansion of A.C. mains supply systems the demand for vibrator-powered radio sets will be on the decline, it may reasonably be anticipated that as the supply and import situation is eased the demand for car radio sets will steadily mount and the majority of these will probably be powered from vibrator packs. The servicing technique for such units is not very different from that required for the mains counterpart, but they do possess certain peculiarities of their own which require to be realised for efficient maintenance.

TYPES OF VIBRATORS

Apart from varied pin bases, there are two main types of vibrators in common use: (1) the non-synchronous, and (2) the synchronous vibrator. The principles of operation are essentially the same, but

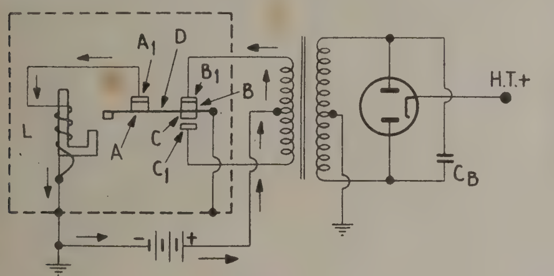


Fig. 1.

the former requires the addition of a rectifier valve while the latter is self-rectifying. The development of the latter will be readily seen from consideration of the non-synchronous circuit shown in Fig. 1 where the vibrator unit is enclosed in a broken line. Fig. 2 shows the actual construction of the vibrator, the letters corresponding to those of Fig. 1. The reed D, consisting of two thin spring steel strips, carries the platinum contacts A, B, and C. The upper ends of the strips are secured to a soft iron bar to form an armature close to which is the electro-magnet L. Opposing the contacts are three others, A_1, B_1, and C_1, mounted on rigid supports which are electrically isolated. The lower end of the steel reed is firmly anchored to the main metal framework which is connected to the earth pin.

Normally, matters are so adjusted that contacts A, A_1 and B, B_1 are just closed. On switching on the battery there is a flow of current through one-half of the primary of the transformer to earth via the reed and contacts B, B_1, while L becomes energised by current flow through the coil to earth via the reed and contacts A, A_1. The reed armature is then attracted away from its normal position to open the A and B contacts and make the C, C_1 contacts so that the current has now to flow through the other half of the transformer primary (and therefore in the reverse direction) and, via the reed and contacts C, C_1 to earth. Meantime L is being de-energised as no current is flowing through it. The reed then springs back to its normal position and the whole cycle is repeated. The rapid reversal of the primary current simulates the familiar A.C. supply and induces a rapidly reversing current in the transformer secondary and is then rectified by the valve in the normal manner.

The above action is probably familiar to all but it has been given deliberately on account of what follows. If sparking at the contacts is to be reduced it is essential that the break action of the reed be very sharp and that the contact faces very flat and true. The air gap between the contacts needs to be very carefully adjusted to suit the spring action of the reed—the natural frequency—and to allow for

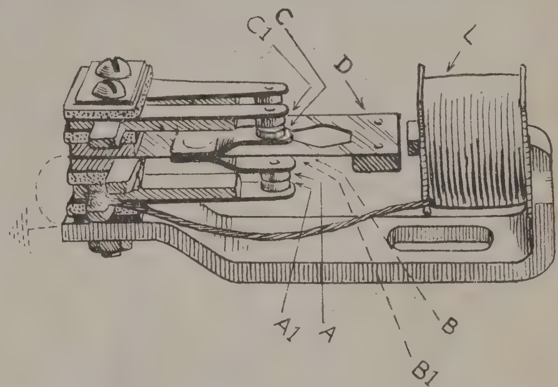


Fig. 2.

the correct "dwell" period on making each contact. These matters are conscientiously dealt with by the designer and the manufacturer and unless servicemen happen to possess special data for any particular make, it is NOT sound practice to attempt to make adjustments "blind."

Some sparking is bound to occur in spite of the addition of buffer condensers or resistors, and this causes the generation of irregular sparking frequencies which force their way through the filter systems

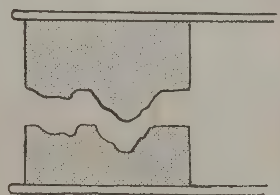


Fig. 3. Showing how pitting of vibrator contacts takes place.

and produce "vibrator hash." Excessive sparking will loosen minute particles of metal from one contact and "weld" them on to the surface of the other as shown in an exaggerated way in Fig. 3. This irregularity causes increased sparking to take place and matters become rapidly and cumulatively worse till a stage is reached when the two faces become permanently joined and so render the unit inoperative.

Pitted contacts can be attended to in the early stages by the careful use of a special flat contact file to restore the surfaces, and remove the black oxidation. If the pitting is bad much filing will be required and this will upset the air gap adjustment. Bending of the stationary contact carriers, unless very skil-

fully done, will disturb the contact angle, presenting only an edge to the mating contact instead of the full face. The contact carriers have to be bent twice, once to close the gap and then to restore the mating angle, and, at the same time, leave the air gap exactly correct. This distance is unknown unless special data is available. Reasonable accuracy can be attained through the medium of an oscilloscope whose vertical plates are connected (via the Y amplifier) across the transformer primary and noticing the waveform for various adjustments. This aspect will be dealt with again later.

The point of these remarks is that it is not economically sound to attempt to repair vibrators in bad condition, replacement with a new unit is the only solution fair to customer and serviceman alike.

These remarks carry still more force when dealing with synchronous vibrators. By eliminating the rectifier valve and adding contacts to the unit for connection to the terminals of the transformer secondary as shown in Fig. 4 a similar result is achieved as will be seen by consideration of the simplified diagrams of Fig. 5.

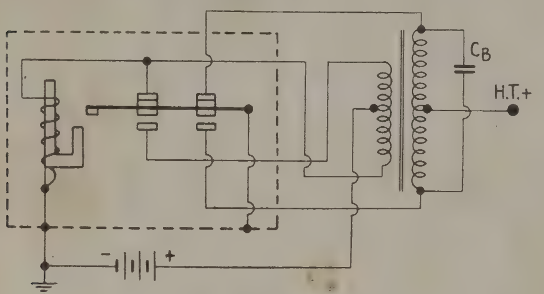


Fig. 4.

The step-up ratio of the transformer will be such as to convert the 4, 6, or 12 volt supply to 150 or more volts on the secondary, and this will render the secondary contacts much more liable to sparking damage, so that the adjustment of the contact air gaps in association with the value of the buffer condenser is even more critical.

VIBRATOR TESTING

The oscilloscope offers the readiest means of effecting adjustments to both primary and secondary parameters. Various arrangements may be encountered such as having small resistors, of about 100 ohms each, commoned to ground and connected to the two sides of the transformer primary to serve as current limiters, or we may find one or two similar condensers instead. On the secondary side we may find one buffer condenser across the whole winding, or with a current limiting resistor in series with it, or two similar condensers commoned to ground and connected to the two ends of the secondary and so on. The value of the buffer condenser is critical as it is selected for the particular vibration frequency of the unit. As it will have to withstand high voltage surges it is essential that any replacement condenser should have a high D.C. working rate of not less than six times the peak secondary voltage, which, please remember, is not the R.M.S. value.

The ideal waveform from either the primary or secondary transformer terminals is a square wave as shown in Fig. 6 at (A), but as some time must be allowed between break and make the vertical lines must be replaced by slightly sloping ones as at (B). The nearest practical approach to this ideal is shown at (C) and (D) for non-synchronous and synchronous vibrators respectively. The corner pips in (D) are due to voltage drops in the primary when the secondary load is connected. The flats or make

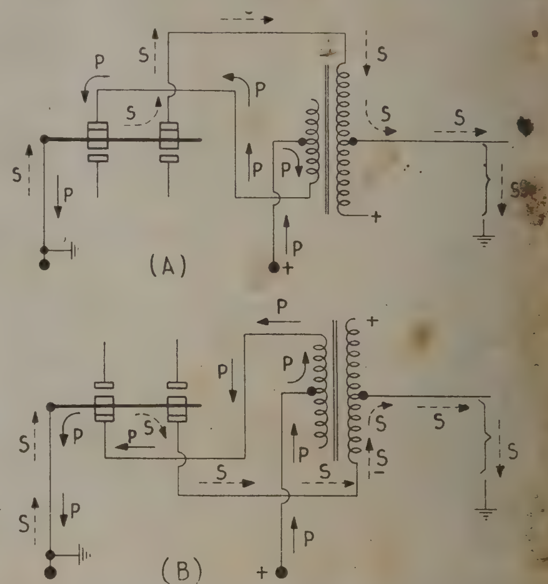


Fig. 5. Illustrating the self-rectifying action of a synchronous vibrator at (A) and (B). The current directions are shown for the two contact positions of the reed.

"dwells" should be about 80 per cent. of a half-cycle, while the inclined thick stroke (current decrement due to inductance) should be about 60 per cent. of the height. (E) shows the effect of too small a capacity for the buffer condenser and (F) the result of too high a capacity. At (G) one contact side is not mating properly through mal-adjustment or worn out contacts—the defect is called "single footing." (H) shows the effect of contact "chatter" due to the loss of vitality of the reed—both (G) and (H) call for replacement with a new unit. At (I) there is no load, and hence pronounced peaks, as well as no buffer capacity, perhaps through open circuit. R.F. sparking frequencies are superimposed. (K) is similar except that the load is present and hence the peaks have been eliminated.

If an oscilloscope is not available we must judge matters by eye and try out various buffer values to reduce the sparking as far as possible without reduction of the H.T. supply—the examination always being carried out while the unit is running under full load.

As an initial test of a vibrator a "starting test" should be taken. A good 6-volt vibrator should run **steadily** on voltages varying from 5 to 7.5 volts, and a 12-volt unit on 10 to 15 volts. The steadiness of running can be judged by inserting a milliammeter in the H.T. supply line, the needle remaining almost

perfectly still. For the starting test the supply to the transformer primary is taken via a rheostat with a voltmeter in shunt and the voltage is steadily increased from about 4 volts (for a 6-volt unit) upwards. The vibrator should start at 5 volts and certainly not later than 5.2 volts. If it does not function till 5.6 volts is reached it should be replaced.

THE POWER PACK AS A WHOLE

The design of these will vary according to the particular requirements, that is, whether they are required for car radios or domestic sets. The reason for this is that the car unit has to have additional filters to eliminate sparking frequencies from the

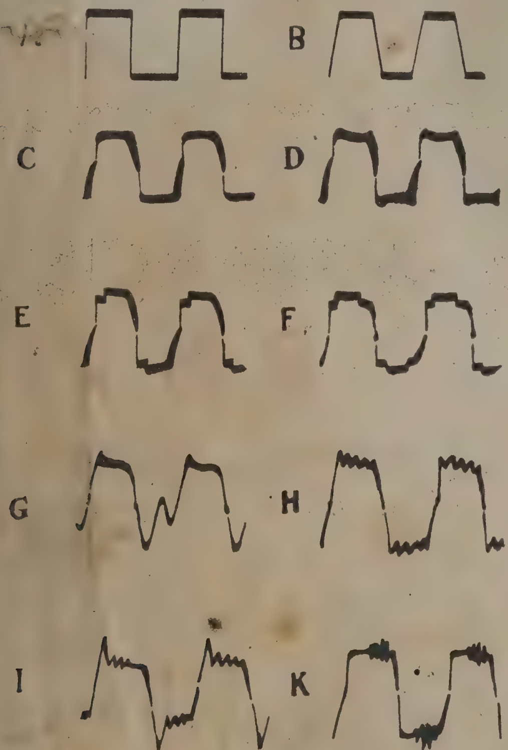


Fig. 6.

plugs, generator, etc., while the domestic set has only to cater for transients passing through the battery from the vibrator circuit. The filters are of the inductance/capacity type to avoid unnecessary voltage drop in addition to that in the battery leads and associated wiring (which should be of stout current carrying capacity to reduce resistance to a minimum). Fig. 7 shows a typical circuit for a non-synchronous domestic set unit with practical values for components and Fig. 8 shows a synchronous vibrator circuit for comparison. Fig. 9 gives a complete circuit suitable for use with a car radio. It will be noted that in each case an R.F. filter is connected in the battery line to the primary centre tap, the inductance consisting of some 50 turns of heavy gauge copper wire —pile or bank wound coils are preferable as they give a higher inductance. The car set of Fig. 9 has R.F. input filters each side of the switch and another in the heater line, usually located in the receiver section at the first heater pin.

A difference will be noticed in the secondary side of Figs. 7 and 8, in that when a non-synchronous unit is used the centre tap is grounded in a manner often found in A.C. mains transformer practice.

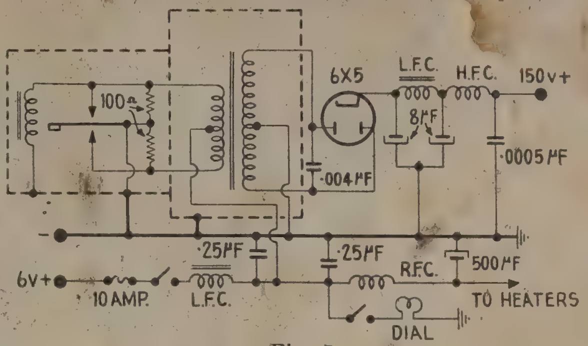


Fig. 7.

because the H.T. is derived from the cathode of the rectifier valve. In Fig. 8 the centre tap is connected to the H.T. line. The H.T. line carries the conventional smoothing filter section and this may be

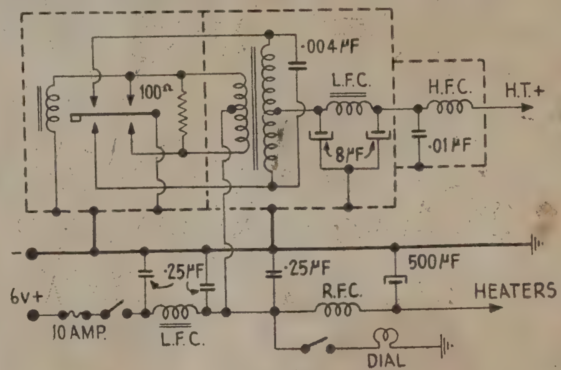


Fig. 8.

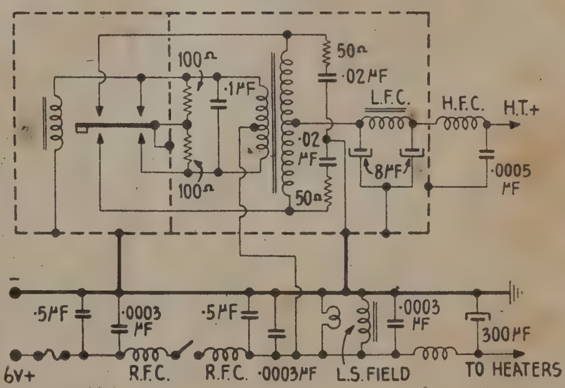
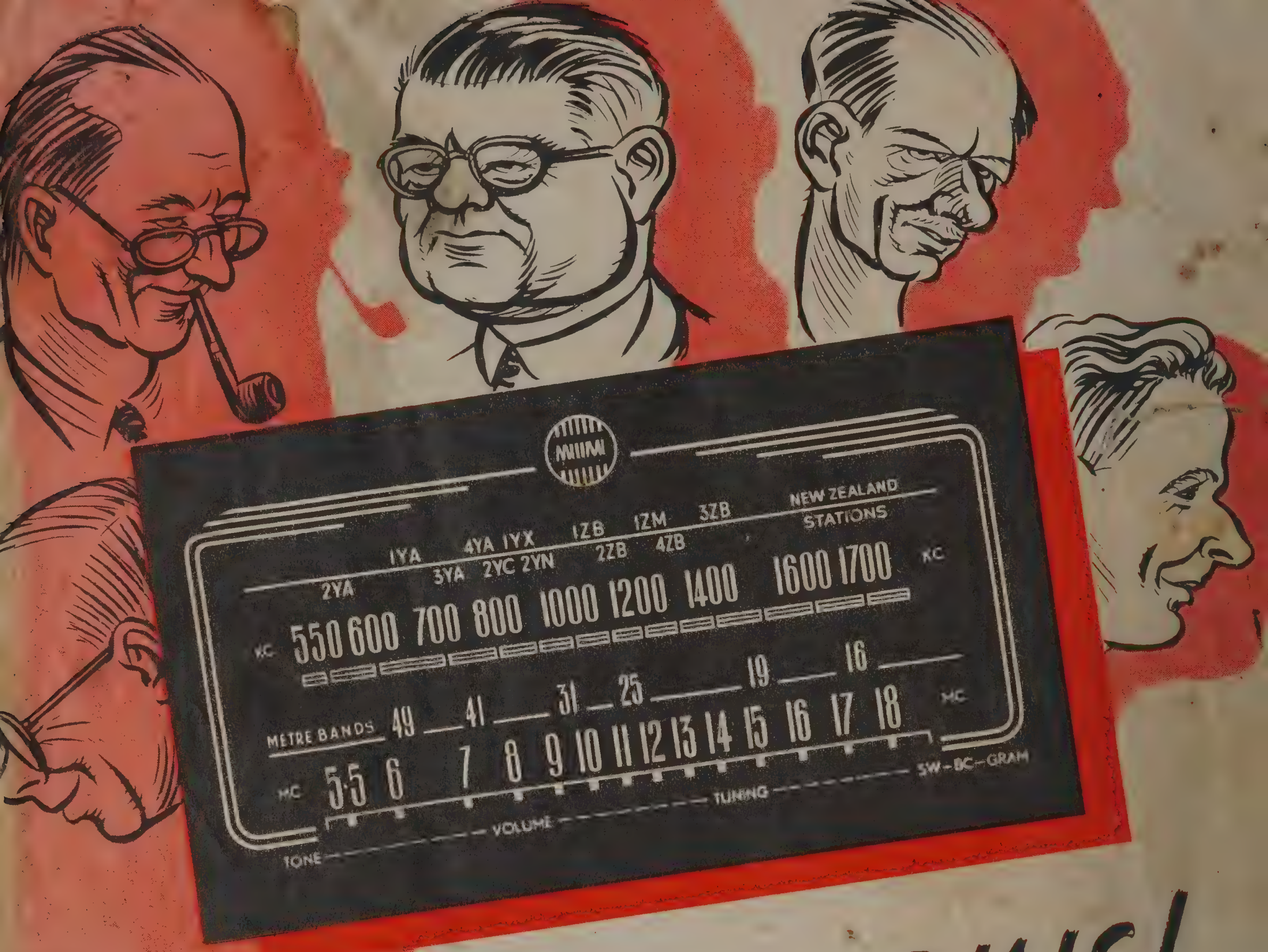


Fig. 9.

followed by a second L.F. choke or an H.F. choke filter, for hash elimination.

The vibrator section up to the H.F. choke filter should be completely screened from the radio set, and if built as a separate unit, the earthing leads


NEW ZEALAND STATIONS
2YA 1YA 3YA 4YA 1YX 2YC 2YN 1ZB 2ZB 1ZM 4ZB 3ZB
KC 550 600 700 800 1000 1200 1400 1600 1700 KC
49 41 31 25 19 16
METRE BANDS
MC 5·5 6 7 8 9 10 11 12 13 14 15 16 17 18 MC
TONE VOLUME TUNING SW-BC-GRAM

from the chassis to vibrator case should be of thick braided wire to offer the minimum ohmic resistance, otherwise if thin wires are used R.F. voltage will be built up across the resistance of the wire, small though it may be, and so be radiated to the antenna or other R.F. wires in the receiver section.

The power transformers are specifically designed for vibrator units using special iron cores of low flux density, and replacements should be made via the manufacturers.

Lastly, fuses should be present in the battery supply line in case a fault develops which entails the passing of excessive current which is likely to damage the contacts. If a fuse is not incorporated the omission should be rectified with a fuse of the correct value, that is about twice the normal battery drain.

GENERAL SERVICING

No special practical technique is called for as the faults likely to be encountered are the normal ones of faulty condensers, connections, resistors or coils. The main requirement is a thorough knowledge of the make-up and operation of the vibrator as outlined above. But there are two main lines of approach, (1) if a variable D.C. H.T. and L.T. supply is available, as from a mains-driven power pack, the vibrator unit may be disconnected and the receiver section tested first, or (2) we can check the vibrator first. In this case it is advisable, after the usual preliminary visual inspection and perhaps continuity tests of the circuit, to isolate the buffer condenser and test it for goodness by means of a Megger or Neon lamp test. When this is proved to be correct it is time enough to connect up with a battery to test the vibrator itself.

If the vibrator buzzes but the H.T. is low the probability is that it is "single footing" (Fig. 6 (G)) and a substitute should be tried. If the H.T. is now correct we can remove the vibrator from its screening can and inspect the contacts.

If the H.T. supply is correct but the receiver shows up much "hash" interference we must check up on the smoothing filters as these are the most likely offenders if the set has been running satisfactorily previously. With newly constructed sets other problems arise as the pick-up must be searched for in the wiring (not forgetting the heater line) and general layout. If the filters prove to be in order but the hash continues, a replacement of the vibrator should be tried as there may be excessive sparking present —the replacement should be a replica of the vibrator or we may have to make modifications to the buffer condenser. If all else fails adjustment of the buffer condenser value can be tried, or substitute other condensers of the same nominal value as the actual value may happen to be unusually critical.

"NOISE ON THE AIR"

By IAN COX.

LONDON, 7th October, 1947.

In the scientific news this week are two items representing the extreme ends in the field of electronics. At one, we have the Pageant of British Radio at the Olympia in London, where all the latest practical results of radio research and manufacture are being displayed; at the other is a very important communication summarising all knowledge up to the moment on "radio noise." These examples of industry and research, however, are intimately connected; for, excellently designed and presented as modern British radio equipment is, programmes will continue to be marred, and telegraph signals made unreliable, until we have got the better of interference originating outside the receiver. The beginning of such mastery must be in the complete understanding of the nature of the interference and this report (Radio Research Special Report Number 15) by Dr. H. A. Thomas and Mr. R. E. Burgess of the National Physical Laboratory, unquestionably leads the way.

The propagation of radio waves, which permits wireless communication, is now fairly well understood and we are in a position to make predictions for successful operating in specific conditions. But satisfactory communication depends also on a minimum ratio of unwanted noise to the signal being read, and the lack of knowledge on this subject has definitely been retarding the solution of quite a number of our communications problems.

Dr. Thomas and Mr. Burgess recognise the four main sources of interference which they classify as man-made, receiver, and cosmic or extra-terrestrial atmospheric. Nowadays the first two of these are not serious.

The cosmic noise that is interference originating from outside the earth is the main nuisance on frequencies between 15 and 30 megacycles per second (10 to 20 metres of wave-length). It produces a steady hiss in the receiver. Its origin is considered to be closely connected with the milky way, of which the Solar System is a very small component. Interpretations of cosmic noise, therefore, depend on a correlation with contemporary astrophysical knowledge. Cosmic noise, by the way, should not be confused with cosmic rays which consist of very high-speed charged particles and are uniformly distributed over the celestial dome. The intensity of cosmic noise as we receive it, is determined mainly by ionospheric absorption and the direction of the centre of the milky way, its reception will be significant only at restricted periods dependent on the position of the observer in respect to the celestial sphere. A great deal still remains to be learnt about the origin of cosmic noise and the Report urges for more experimental work to establish its source more definitely and a more theoretical enquiry into the mechanism of its production.

Atmospheric noise is a source of interference familiar to us all. Just as cosmic noise matters most at the higher communications frequencies, so, below about 20 megacycles per second (that is with wavelengths of more than 15 metres) the useful sensitivity of a receiver is limited principally by the level of atmospheric noise. This noise may assume one of several forms, but there is no evidence that these forms have a different origin. It may be a "click" (a single short disturbance composed of a very few impulses), a "grinder" (a series of disturbances lasting a second or more, or several strong disturbances occurring concurrently), or a "sizzle" or "hiss" (a rapid repetition of a large number of disturbances of comparable intensity).

Atmospheric noise is produced principally by radiation from lightning discharged and all thunderstorms within 6,000 k.m. of a receiving station are potential sources of interference.

The radiation field produced results from a large number of individual impulses, the mean duration of each being about 6 micro-seconds. The number of impulses received from a large distant storm centre is about 30,000 each second. This figure is important because interference, as judged by the listener or receiving operator, is not only a matter of peak or average field strength, but also the number of disturbances a second.

The most persistent centres of these storms lie chiefly over the tropical land masses during the local summer season. From April to September, for example, we find them over South-Eastern United States and Central America, Central Africa and the Malay-Philippine area. In October-March, they are over Peru, Brazil and its Atlantic seaboard, South America, North Australia and so on. Overland thunder-storms are most active during the afternoon and early local time; over the sea they may last much longer—maybe as much as 72 hours.

It has been calculated that about 2,000 storms are

(Continued on page 56.)

A Practical Beginners' Course

PART 17

Last month we gave a very brief description of how the regenerative detector circuit of Fig. 28 works, but without any mention of the functions of C_3, L_4, and C_4.

The purpose of C_3 is to control the amount of feedback (or regeneration) so that the detector may be placed in its most sensitive condition for receiving distant stations, or may have the sensitivity reduced until there is very little regeneration at all, for receiving strong stations. Very roughly, C_3 may be called the volume control of the set, since this is one result of the manipulation of C_3, but it has other important functions as well.

You will remember that the tuned circuit L_2C_1 itself acts in such a way as to amplify the minute signals passed on by L_1. Now, if the coil of which L_2 is made had no resistance at all, the amount of amplification it could produce would be unlimited. This would be very convenient if it were practicable, but it is not, owing to the fact that every coil has **some** resistance, even if it is small. In practice, a coil can have an amplification of 100 to 200 times. This seems quite a high figure, but when it is realized that weak signals are as small as a few millionths of a volt and that a substantial fraction of a volt is required to give a reasonably loud signal in the headphones, it can be seen that an amplification of 100 or 200 times is hardly enough to give reception over very long distances.

Now, when regeneration is used, the actual effect of this is the same as if the coil L_2, in its tuned circuit, was made with very much less resistance than it actually has. Thus the coil is able to give an amplification of as high as 10,000 times, which is enough for very weak signals indeed to be made available. Local stations, however, are able to produce signals of several volts at the aerial terminal of the set, so that if it had as much amplification as this at all times, the set would be very badly overloaded by such local signals, and the result would be very heavy distortion. This is why some means must be provided for reducing the amplification of the set so that it can handle without distortion the larger local signals.

PURPOSE OF L_4 AND C_4

With a set such as this, which has so much amplification, it is necessary to prevent the amplified R.F. voltages from appearing across the headphones. If this is not done, the set can become quite unmanageable, producing howls and squeals instead of stable amplification. L_4 is a coil of very much higher inductance than L_2, and has the useful property of preventing R.F. currents from flowing through it, and therefore from flowing through the phones. It is popularly known as a **radio frequency choke** (R.F.C. for short) because of this property, and such a choke is often used where it is desired to prevent R.F. from entering a certain part of a circuit. The choke has no effect on the audio frequency currents passed through the phones by the detector, simply because its inductance is not great enough for it to affect audio frequencies.

The condenser C_4 is a small one, whose purpose is to short-circuit to earth any R.F. that may not be stopped by the choke. Here again there is no effect upon the audio frequency currents, because the value of C_4 is so low that at audio frequencies it does not pass any current at all, or at least so little as makes no audible difference.

At this stage it is not easy to describe the exact action of C_3, so no attempt will be made to do so, but the manner in which it acts is that at its maximum capacity setting (i.e., with the moving plates right out) there is very little feedback, while with maximum capacity the feedback is a maximum.

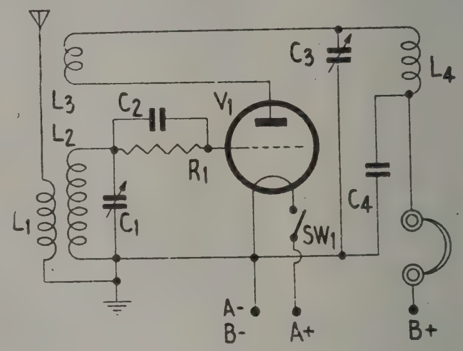


Fig. 28.

OSCILLATION

If any circuit such as that of Fig. 28 is adjusted so that the feedback is more than a certain amount, the amplification is so great that the circuit becomes an **oscillator,** or a generator of R.F. currents. It becomes, in fact, a miniature transmitter, sending out from the aerial waves of the frequency to which the tuned circuit L_2C_1 is tuned. We do not intend at this stage to go into the whys and wherefores of oscillators, except to note that in a receiver of this kind, the oscillation that takes place is very useful, and may be turned to good account.

Just how this comes about, we shall see when it comes to describing the operation of this set.

CONSTRUCTION OF THE COIL

The most important thing in getting a set such as this to work well is the construction of the coil, comprising L_1, L_2, and L_3. In the first place we will confine ourselves to the broadcast band, for it is quite easy to get going there, and after a little experience has been gained we will be in a position to try shortwave reception using the same circuit.

For best results, the broadcast coil should be a large one, wound on a 3 in. diameter former, similar to the one used for our crystal-set coils. In fact, the original coil that was made for the crystal set shown in fig. 3 (Beginners' Course, Part 3, October, 1946) may be used, with the addition of the third winding L_3.

L_2, it will be remembered, consists of 70 turns of 24-gauge D.C.C. wire, close-wound on the 3-inch former, and L_1, the untapped aerial coil, comprises 30 turns wound above L_2 so that ¼ in. space is left between the two windings.

The regeneration or **reaction** coil, L_3, is wound

directly over the bottom of L_2, so that the turns sit in between the turns of L_2. This is not difficult to do, the only thing requiring a little care being the finishing off of the winding. A start is made in the usual way by pulling the end of the wire through two small holes made in the former just below the winding of L_2. About six inches of wire is left to be used as a lead for the lower end of L_3. The easiest way to ensure that L_3 will stay properly in place is to paint over the bottom 12 turns of L_2 with shellac varnish or with some non-water soluble glue such as casein glue or "Ataglu." Then the 12 turns of the reaction winding are put on, and the last turn is held in place by taking two or three turns of wire round the coil, higher up than where the glue is, and fixing the end so that the turns cannot slip. When the glue is dry these extra turns can be allowed to unwind, and the coil will be held by the set glue.

An alternative method of fixing the finishing end is to use a fine awl or heavy darning needle to make two holes between the appropriate turns of L_2, which can be very lightly pushed apart for the purpose. Care must be exercised in making these holes in case the cotton insulation is cut through, but otherwise no difficulties occur.

WIRING UP THE SET

When the coil has been constructed, the wiring-up can start. A piece of inch-thick wood can be used as a base-board, and for this set, unlike the previous ones we have built, it should be provided with a metal panel. The two variable condensers can be mounted either on the panel or on the base-board, according to how they are made, but the best ones to use are the all-metal types such as were used for our crystal sets, and which are mounted by small feet to the base-board. Two small holes will then need to be drilled in the panel to allow the shafts to come through. The condensers should be mounted about four inches apart, so that there will be room for a reasonably large dial on the tuning condenser C_1. The regeneration condenser, C_3, needs only a small knob, although a large one is of assistance when ticklish adjustments have to be made. The coil should be mounted directly behind the tuning condenser so that the leads between L_2 and C_1 can be kept as short as possible. The valve socket is mounted beside the coil, and quite close to it. It is a good plan, too, to mount a phone jack on the front panel, and to mount a row of four fahnstock clips behind the coil and valve socket. The left-hand one can be used for the aerial, and the other three for connecting the batteries. The A battery switch can be mounted on the front panel also.

Wiring the set is no more difficult than wiring any of our previous crystal sets, but there are one or two precautions that should be taken. The leads from L_3 to the valve and C_3 must be connected the right way round, or the set will not work at all as it is meant to. In the diagram, Fig. 28, the correct connections are as shown, **so long as all windings are in the same direction.** Since L_3 is wound in the spaces between the turns of L_2, it must be wound in the same direction as L_2, so that the **bottom** of L_3 must go to the plate of the valve, and the top to the fixed plates of C_3. On no account should the moving plates of C_3 be connected to the regeneration winding, and the fixed plates to the earthed side of the circuit. The same applies to C_1. The moving plates (which are connected to the frame) should be taken to the earth side of the circuit, and the fixed plates to the junctions of L_2, C_1, and R_1.

OPERATING THE SET

This will have to be treated in detail next month.

(Continued on page 56.)

A Practical Analysis of Ultra High-Frequency Transmission Lines, Resonant Sections, Resonant Cavities & Wave Guides

By J. R. MEAGHER and H. J. MARKLEY, R.C.A. Service Company Inc.

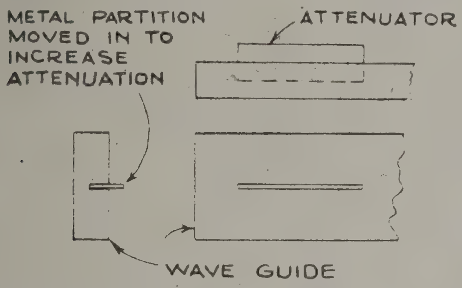
PART VI

PRACTICAL FACTS ABOUT WAVE-GUIDES
(Continued.)

(7) For some purposes, usually test, a wave guide may be matched to air by increasing the internal cross section of the guide slightly at the "air" end; normally an R.F. choke, as shown above, is also used.

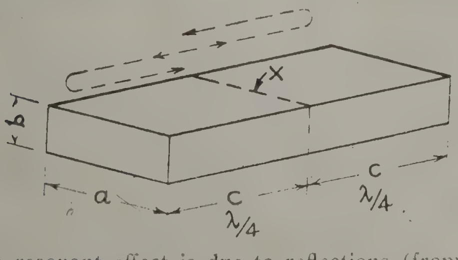
The end of the wave guide may also be flared outward (increasing the cross section) and used for radiation.

(8) A wave-guide attenuator may consist of a movable metal partition as shown below, the attenuation increasing as the partition is moved in.



(9) Standing-wave ratios are checked in a manner similar to that used for a co-axial line. A section of wave guide with a narrow slot parallel to the axis of the wave guide (located in the maximum of the electro-static field) is used. A probe with a "cystal detector" or an instrument fuse (1/200A heated to almost the blowing point by D.C. is used to detect the presence of standing waves, as with a slotted co-axial measuring line. Due to much higher frequency, measurements are considerably more delicate.

(10) A section of wave guide may be used as a tuned circuit or as a transformer. In this accompanying illustration, if R.F. energy is introduced at "X," reflection will occur at the closed ends. If dimension "C" is correct, the R.F. voltage will be reinforced at "X." In this example, "C" is a quarter of a (guide) wavelength; however, other lengths may be used as long as the reflected voltage arrives back at "X" in phase with the R.F. source.

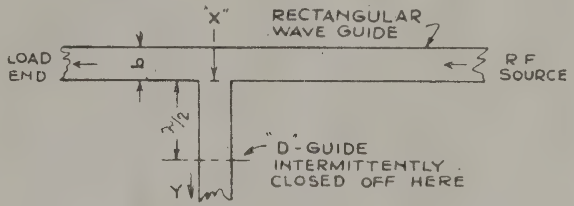


The resonant effect is due to reflections (from the closed ends) setting up standing waves in the guide. The action is similar to that of a "cavity resonator."

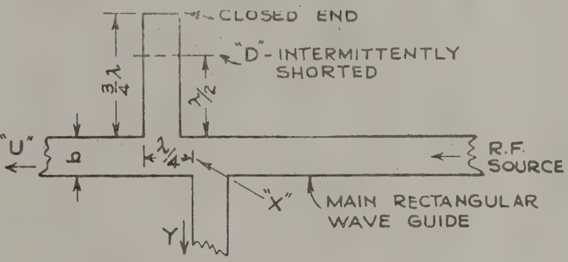
The R.F. energy may be introduced inductively, capacitively, or by radiation. Output may be obtained in a similar manner.

(11))Sections of open and closed wave guides may be used in switching circuits, etc. In the following examples, where a quarter or three-quarters wavelength is indicated, an odd multiple of a quarter wavelength may be used. Where a half wavelength is indicated, any multiple of a half half wavelength may be used. (Electrical wavelength in the guide is referred to, not physical length.)

In the illustration below an intermittent short at "D" (mechanical or by means of a special tube) is used. A short at "D" will result in effectively a "solid wall" looking in at point "X" when "D" is shorted.



In the following illustration an intermittent short at "D" (mechanical or by means of a special tube) is used.



When "D" **is shorted,** effectively a "solid wall" will result at the junction of the closed stub to the main guide. Paths "Y" and "U" may receive energy.

When "D" **is not shorted,** effectively a "solid wall" will result looking in at point "X," which is two half-waves (a full wave) from the closed end. There will be no transmission in the direction "U," but there will be transmission in direction "Y."

(12) A typical wave guide in practical use now, which happened to be a standard size of rectangular tubing:—

Width: About 1.5 per cent. greater than half wavelength (about as small as can be used).
Thickness: About 44 per cent. of the width.
Wavelength: About 40 per cent. longer than in air (standing-wave measurement).
Standing-wave Ratio of as high as 3 to 1 may be tolerated.

CAVITY RESONATORS

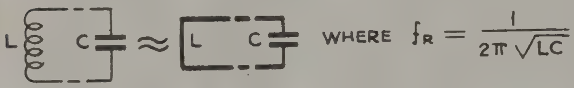
Cavity resonators are tuned resonant circuits for extremely high frequencies where it becomes impos-

sible or impractical to use tuned lines or lumped circuits.

No unique definition of L, C, and R can be found in a cavity resonator. A cavity resonator is similar to a wave guide in that electro-magnetic lines of force oscillate back and forth within the cavity in some particular mode, depending upon the shape and method of excitation of the cavity.

UHF cavity resonators may be compared to conventional acoustic resonators. An example is the boomy sound in a room with smooth hard surfaces (good acoustic reflectors). Sound from a source will be reflected from wall to wall with only slight absorption of energy at each reflection. If the frequency of the sound is such to produce standing waves between two surfaces, or combination of surfaces, the sound is reinforced. The resonant frequency depends on the room dimensions. The "Q" depends on the reflectivity of the walls and other losses.

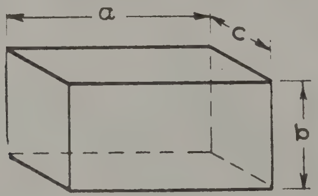
DEVELOPING A SIMPLE RESONANT CAVITY



If it is desired to increase the resonant frequency, we can parallel the inductances "L," thus making the equivalent "L" quite small. There are limits as to how small "C" may be made practically, so the only thing left to do is to decrease the effective "L" of the circuit in order to tune to a higher frequency. See diagram.

As shown above, more and more inductive stubs may be added, thus decreasing the effective "L" and increasing the resonant frequency. If this is carried on to the extreme, a closed chamber or resonant cavity results. (Strictly speaking, it is not proper to talk of the inductance of a cavity resonator.)

MODES OF OPERATION OF CAVITY RESONATORS



Consider a rectangular section. The description of the "Mode" would be given in terms of electromagnetic fields and various frequencies. Various frequencies of oscillation (different modes) are possible, because wave energy may be propagated and reflected from various surfaces. There is also the possibility of an oscillation that is a harmonic of the basic wave. Two important points in cavity resonators are: (1) how oscillations are formed, and (2) how energy is removed. They will affect the mode of operation.

The R.F. energy may be introduced to or removed from the resonant cavity, inductively, capacitively, or by radiation.

The energy is in the electrostatic field at one instant and in the magnetic field an instant later, oscillating from one field to the other at the frequency of the applied energy.

In referring to cavity resonators, the idea that a conductor is always an "equipotential surface" is untrue; voltages and currents reverse themselves in a space measured in centimetres. An **electrostatic field** can terminate only on electrical charge, hence there must be appropriate distribution of charge on the surface. A **magnetic field** can cease suddenly only on a surface carrying current, hence there must be current flowing in the inside surface of the resonator (only penetrates a very thin skin of the metal surface and cannot be detected on the outside of the resonator).

A general statement, for simple resonators, can be made that it is necessary to have a dimension of an electrical half-wave or multiples of a half-wave, since the electrostatic field is a maximum at the centre and minimum at the sides of a simple resonator, otherwise the electrostatic field would be shorted out. (Refer to the data covering a section of wave guide used as a tuned circuit.)

RESONANT FREQUENCY "Q" AND "Ro"

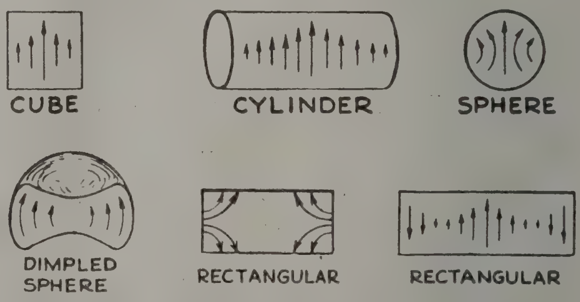
The resonant frequency can be calculated from the shape of the cavity for very simple types of resonators possessing symmetry.

The "Q" can be determined through knowledge of the rate at which energy is lost. A large "Q" may be obtained when the ratio of volume to surface is large. Approximate values of "Q" may be 28,000, 31,000, and 26,000, for a cube, cylinder, and sphere, respectively, when not loaded. High "Q" does not necessarily imply high shunt resistance ("R") in a resonant cavity.

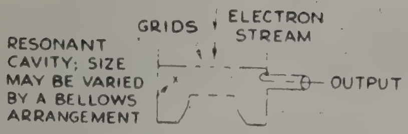
FORMS OF ACTUAL CAVITY RESONATORS

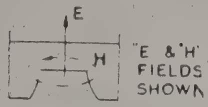
Cavity resonators may take various shapes such as cube, sphere, cylinder, sphere dimpled on top and bottom, cylinder "dented" at one end (with ends forming grids as in an H.F. tube, for instance), etc.

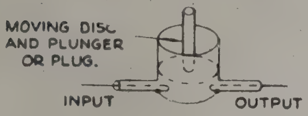
Several possible types of cavity resonators are shown below. The electrostatic lines of force are shown for one possible mode of operation:

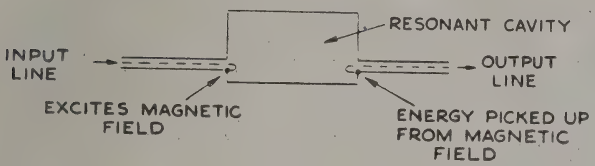


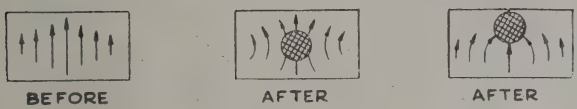
The cavity (box) cannot resonate if it is too small for the wavelength concerned. If the R.F. energy is the correct frequency for the cavity, high amplitude centimetre waves (fields) will propagate across from top to bottom of the cavity.











TUNING SLUGS FOR CAVITY RESONATORS

For the purposes of explanation, a metal sphere is shown in a rectangular resonant cavity, with the "E" lines of force for this particular operation as shown below:

(1) The slug shortens electrostatic (E) lines of force, hence the capacity is said to **increase.**

(2) The magnetic (H) lines of force are normally weak at the centre and are not appreciably affected.

(3) The wavelength **increases** (frequency lower).

If the slug is inserted at one side or the other, the result is as follows:—

(1) The slug shortens the magnetic lines of force (H), hence the effective inductance is said to **increase.**

(2) The electrostatic lines of force (E) are normally weak at the side and are not appreciably affected.

(3) The wavelength **decreases** (frequency higher). Since the two positions of the slug, namely, in the maximum (E) field, and maximum (H) field, change the resonant frequency in opposite directions, it would be expected that a position where no change in wavelength would result might be found.

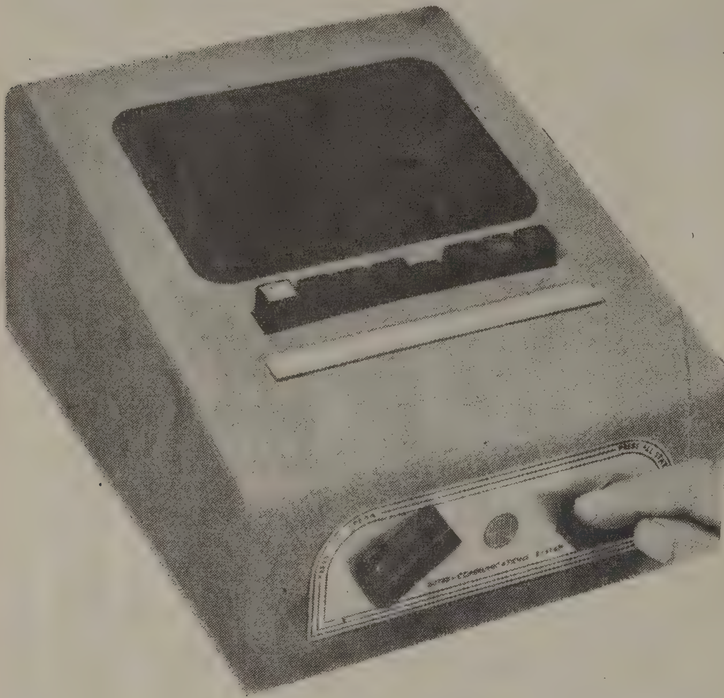
(To be continued.)

"RADIO AND ELECTRONICS"

Back and current numbers of "Radio and Electronics" may be obtained from—

Te Aro Book Depot, Courtenay Place, Wellington.
S.O.S. Radio Service Ltd., Queen St., Auckland.
Tricity House, 209 Manchester St., Christchurch.
Ken's Newsagency, 133-135 Stuart St., Dunedin.

YOU INSURE AGAINST FIRE LOSS! But—
DO YOU INSURE AGAINST TIME LOSS?



Needless walking instead of talking wastes valuable time —and time is expensive.

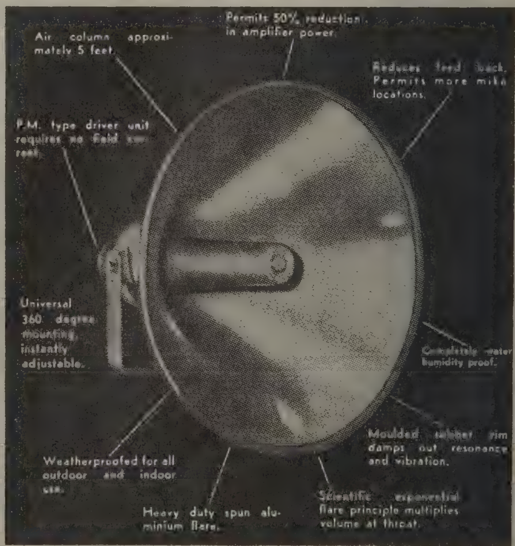
IN YOUR TOWN many business houses, factories and institutions are losing money—through loss of time.

IN YOUR TOWN valuable business is waiting by selling

"ABEC"
INTERCOMMUNICATION
SETS

Amplion Public Address Reflex Projector, Type PA 35

Air Column: 5 ft. approx.
Dispersion: 90 degrees.
Frequency: 115 to 5,000 cycles.
Projection: Up to 1 mile.
Diameter: 25 inches.
Depth: 18 inches.
Weight: 12 lb. approx.
Power: 10 watts.
Voice Coil: 10 ohms.



BRADLEY Electrical Co. Ltd.
57 VICTORIA STREET
WELLINGTON

TRADE WINDS

NEW ZEALAND RADIO MANUFACTURERS' FEDERATION HOLDS ANNUAL MEETING

The annual meeting of the New Zealand Radio Manufacturers' Federation was held in the Board Room of the New Zealand Manufacturers' Federation on 12th November, 1947. Those present included Messrs. W. J. Blackwell, D. T. Clifton-Lewis, T. J. Spencer, Chas. Hart, I. R. Cosgrave, J. M. Gifford, R. Slade, P. C. Collier, W. I. Cunninghame, W. L. Shiel and R. E. Dawson. Mr. W. J. Blackwell was re-elected President, Mr. W. L. Shiel, Vice-president.

With the delicensing of the radio industry and the winding up of the Radio Plan Industrial Committee, problems affecting the radio industry now come within the province of the Radio Manufacturers' Federation, the work of which has and will greatly increase.

In presenting the annual report, Mr. Blackwell paid tribute to the work done on behalf of the Federation by Messrs. W. I. Cunninghame and D. T. Clifton-Lewis, who have devoted a great deal of time and energy to looking after radio manufacturers' interests in connection with matters dealt with by the Radio Plan Industrial Committee, the War Assets Realisation Board, and also in connection with the Patents and Royalties Agreement. Mr. Blackwell also mentioned the indebtedness of the Radio Manufacturers' Federation to Messrs. F. W. Mountjoy, H. W. Alston and P.C. Collier for the interest they have taken in the affairs of the industry as its representatives on the Radio Plan Committee.

In summarising, the President emphasised that, with the delicensing of the industry, the need for a strong organisation to look after the interests of members is greater than it has been in the past. There are very important problems in connection with the supply of raw materials, Patents and Royalties and Price Tribunal matters, which will require to be dealt with on a national basis during the coming year, and it is essential that every member of the Federation should give his own organisation the utmost support.

"In radio receivers," said Mr. Blackwell, "the 'seller's market' has disappeared, and those traders who were beginning to believe that the easy days of more customers than stock were the normal state of affairs now seem to think that trade has tightened. Such, however, is not really the case; it is merely that radio trading is again normal and it is necessary for all connected with the radio business to accustom themselves to such normal conditions.

"Sales of radio receivers are still potentially great, just as much so as ever they were, but more **selling** is certainly necessary than was the case two years ago. The sale of domestic radios should be stimulated by the production of quality receivers coupled with the selling ability to prove to listeners that their old and obsolete sets really need replacement. Sales should **not** be stimulated by the common and dangerous practice of cutting prices, for of necessity these lower prices throughout the industry must mean lower quality. New Zealand is producing domestic receivers of as good quality as those of any other country—and usually to much closer tolerances—and all manufacturers should strive to maintain the standards of technical excellence that have brought such a high and justly deserved reputation for the New Zealand-produced radio receiver."

Mr. Cunninghame presented figures illustrating the remarkably low price increase of domestic receivers, using as a basis of comparison a selection of receivers ranging from 5-valve broadcast to 7-valve bandspread consol radio-gramophones. Present radio set prices have increased only 31.42 per cent. over the 1939 retail figures. Of this increase manufacturers' costs account for 19.39 per cent. and sales tax by 12.03 of the retail prices. Sales tax in 1939 was 5 per cent.; now it is 20 per cent.

At the conclusion of the meeting, which lasted a full day, the Radio Manufacturers' Federation entertained guests at the Royal Oak Hotel. Among those invited were prominent Government officials, whose Departments were closely associated with the radio industry.

* * *

Pictured here are Ken Stephen and Basil Clarkson of H. W. Clarke's, giving the "Peirce" wire recorder the "once over."

As supplies become available, wire and tape recorders will find a large place in the commercial and professional worlds. This is an excellent new field for the electronic man. The possibilities of this type of recorder are wide, for this device is being used for dictation, conferences, sales, medical and hospital work, court cases and other legal work, speech courses, dramatics, broadcasting, religion, education, news reporting and every type of training course.

* * *

NEW VALVE DEVELOPMENTS IN RADIOLYMPIA

The poularity of the domestic radio set, in prewar years the main attraction at Britain's great radio exhibition, Radiolympia, this year has been seriously challenged by the Electronics Section. When the Exhibition opened recently, a constant stream of visitors, both home and overseas, passed through this section, where were demonstrated the industrial uses of electrons and their application to communications and navigational aids. An alarm breakage detector which gives warning by sight and sound to the operator if the thread is broken in the bearing; the machine which counts with complete accuracy up to 1,000,000; the instrument which records the moisture content of timber and a new type of panel for resistance for welding control; these are some of the working models at Radiolympia which are convincing the public that the science of electronics is on the way to revolutionizing industry.

British manufacturers are to-day applying electronics to a vast number of processes, which range from the automatic soldering of cans to calculating, colour matching, counting, and traffic control. In nearly every case the new process is foolproof, and can be operated either automatically or by semi-skilled labour. But whatever process for which the electronic equipment is designed, the basis is the same: the thermionic valve.

Stands of British valve manufacturers at Radiolympia attracted particular interest on this occasion. Their exhibits demonstrated that in this field, too, the industries were ahead in the practical application of its technical research achievements.

One industrial valve claimed by its makers to be "the valve of the future," incorporates many important constructional changes. Another interesting new valve from the same firm and shown for the first time was a miniature valve which gives a performance similar to that of full-size counterparts. These miniature valves, developed during the war, made possible the "walkie talkie," which sets up British communication when raiding enemy coasts.

An example of the outstanding advance demonstrated by another leading firm of valve manufacturers is the Sidica envelope. The advantage over the standard glass type is that the valve can be small physically but "large" electrically. Furthermore, the high melting point obviates the need for forced air-cooling. These manufacturers make industrial valves ranging from 250 watts for 4 kilowatts, which are finding many leading applications in electronics.

Such exhibits show the long path which British valves have travelled since they were designed purely for broadcast receivers and transmitters. For instance, they range from a tiny valve no bigger than the top of a little finger—it is used for hearing aids—to a big valve which drives an engine which tells the farmer when his wheat is dry enough to cut. This engine is also used by many flourmillers in the United Kingdom. Another valve is attracting amateur and professional photographers because it produces a flash of one-millionth of a second and lasts virtually for ever— a boon to the press photographer who has hitherto had to carry a load of fresh bulbs. Another new development by the same firm and one which has wide-range industrial uses is an accurate measurement of metres—equipment which can give direct and badly needed accurate measure of acceleration.

The overseas demand for industrial valves such as these is understandably very heavy. This firm, for instance, is sending 70 to 80 per cent. of its products abroad and a good proportion of this is incorporated in radio equipment and industrial devices. To cope with these expanding overseas sales, the main organization has evolved a fine technique in marketing. The old-time "commercial traveller" has been replaced by an engineer-cum-salesman—an expert versed in every aspect and requirement of the valve application, who can answer customers' every question. It has also established technical data, which is always at customers' disposal, as are the full resources of its laboratory and the time and experience of its engineers. British makers of domestic radios pride themselves on their big contribution to industry's export drive, but executive manufacturers are also playing their full part.

QUESTIONS AND ANSWERS

ADDITION OF EXTRA RANGES TO THE ZC1 RECEIVER

F.F.E., Piripaua, writes as follows:—

"I propose to replace the receiver's wave-change switch with a ganged multi-point switch with the object of expanding the range of frequencies covered. Could switches S1/A2, S1/A4, and S1/A6 shown in the ZC1 schematic be omitted without affecting the stability of the receiver to any extent?"

The switches referred to are the ones which short-circuit the low-frequency range coils when the high-frenquency band is in use. Their purpose is to prevent absorption by the low-frequency coils due to their self-resonant frequency possibly lying within the band covered by the high-frequency band. If there is complete shielding between the two sets of coils (and this can never be quite perfect, owing to the capacity between contacts on the wave-change switch), there is no necessity for earthing the unused coils. Many receivers do not employ this precaution, and yet operate quite satisfactorily. Our recommendation is that the shielding between coils on the same switch wafer should be as complete as possible, both by the use of partitions and by placing adjacent coils with their axes at right angles where this is possible. If these precautions are taken, no trouble should be experienced.

* * *

THE CATHODE-COUPLED R.F. STAGE

J.F., Christchurch, writes as follows:—

"Like many others, I have been considering using a cathode-coupled R.F. stage in an amateur band receiver down to 15 or perhaps 10 metres.

"On page 31 of the July, 1947, issue it is stated that above 7 mc/sec., it would be necessary to use a specially designed coil in the plate circuit. Is this because the usual run of commercially-made coils are designed with high impedance primaries to work with R.F. pentodes, whereas the cathode-coupled triode stage needs a lower impedance load? Does this not also apply to the infinite impedance mixer when used with standard I.F. transformers?"

As J.F. suggests, the answer to his first question is tied up with the plate impedance of the tube and the load impedance into which it must work. The difficulty with commercial coils at high frequencies is that they are usually wound with low-impedance primaries—inter-wound with the tuned secondary winding. This arrangement acts as does any other transformer in reflecting across the secondary an impedance related in value to that connected across the primary, and determined partly by the degree of coupling between the two windows.

Since in this type of R.F. transformer the coupling between windings is quite tight, and the plate impedance of the triode amplifier is as low as 7000 ohms, it is possible for impedances as low as 30,000 ohms or so to be reflected across the secondary, drastically reducing its Q, and therefore the stage gain of the amplifier.

Again, the load impedance presented to the tube is much too low to allow the tube to produce much voltage gain.

From theoretical considerations it would appear that the best amplification could be obtained from using a tuned circuit in the plate circuit, but with the plate of the tube tapped down toward the low-potential end. The extent to which this is done would best be determined by experiment.

The same difficulty does not occur when using standard I.F. transformers in the infinite impedance-mixer circuit, because in this case the tube is working at very low plate current, with the result that its plate impedance is of the order of 50,000 ohms or so.

* * *

LOSS OF GAIN WITH THE INFINITE IMPEDANCE MIXER

Quite a number of people who have tried the infinite impedance mixer circuit have been heard to complain about the loss of gain experienced, and the question, "How can I regain the lost amplification of the normal mixer tube?" crops up in our mail-box quite often. One writer has said that the infinite impedance mixer reduced the set noise quite successfully, but was taken out again because of this loss of gain.

We have been at some pains in these pages to point out that if everything else in a receiver is satisfactory, the loss of gain is quite unimportant. This is a fact, but there is a not unnatural tendency among constructors to disbelieve any statement which says that loss of gain is unimportant.

There is definitely an improvement in signal-to-noise ratio on substituting an infinite impedance mixer for any ordinary mixer circuit. That much seems to be agreed. What is not generally appreciated is that the average receiver already has a good deal more gain than is absolutely necessary. Thus, if an infinite impedance mixer is put into such a set, there is only one case in which the conse-

quent loss of gain need be made up for. This is where the set no longer has sufficient gain to give enough audio output on weak stations. Normally all that the gain loss means to the operator of the set is that for weak stations the volume control must be turned further up than previously. Thus, if the set has sufficient reserve gain before modification (and most sets have) there is no need to do anything at all about bringing back the overall gain to its previous level. If something has to be done about this, the required result may be obtained in any way at all. That is to say, extra I.F. or audio gain can be provided, and as far as results are concerned it does not matter in the least which method is used.

For instance, one very easy way of providing extra gain where the original tube line-up used 6K7's in the I.F. and/or R.F. stages is to substitute EF39's for them. At most the substitution will entail a slight change of bias resistor. Similarly, in a receiver which uses two stages of I.F. amplification, there is so much gain available that unless the tubes are biased well back at maximum gain setting, there is no need at all to do any modification to the circuit other than to the mixer stage.

If one of the I.F. stages is normally run at increased bias to limit the overall gain to a reasonable figure, it is possible simply to decrease the bias on this stage until the desired gain is realized. Even in this case a thorough listening test will show such modification to be unnecessary.

The operative word in this last sentence is "thorough," because it may take a good deal of listening

(Continued on page 56.)

TUBE DATA

TYPE 809 TRANSMITTING TRIODE

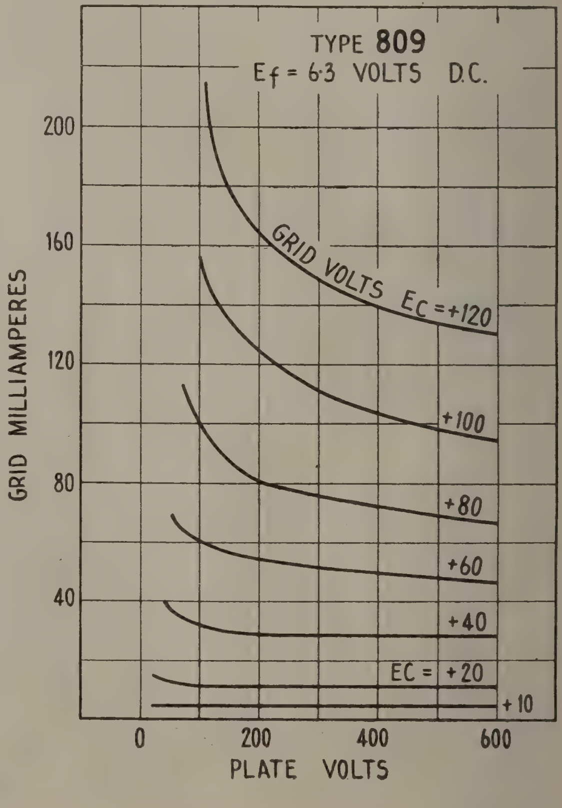
The 809 is a high-amplification-factor transmitting triode rated at 30 watts plate dissipation and 100 watts maximum input I.C.A.S. It may be operated up to 60 mc/sec. with full ratings and at 120 mc/sec. with 50 per cent. of maximum rated plate voltage and plate power input. It is very suitable, too, as a class B audio amplifier tube. At maximum ratings a pair of 809's will give an output of 145 watts with a grid driving power of only 3.4 watts. Ratings and typical operating conditions for a number of types of service are given below.

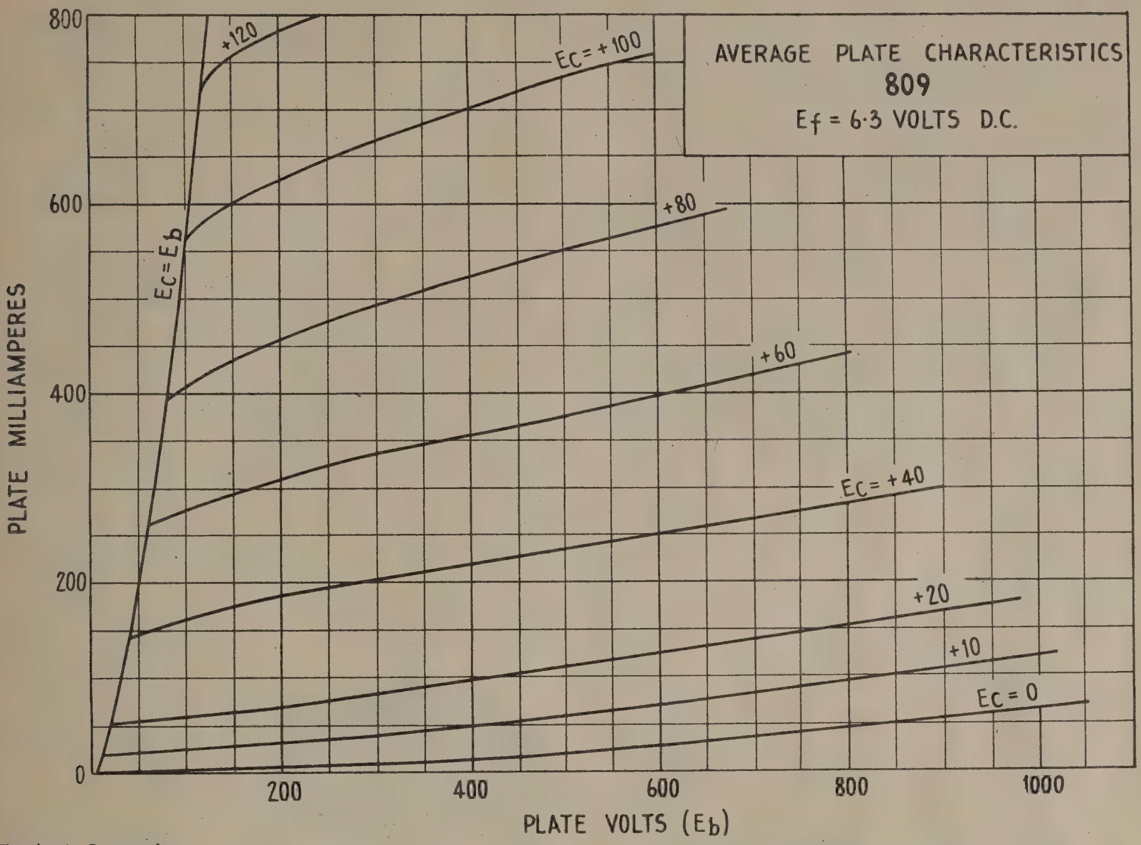
(1) General:

Filament Voltage (A.C. or D.C.)	6.3 volts
Filament Current	2.5 amps.
Amplification Factor	50
Inter-Electrode Capacities—	
Grid—Plate	6.7 mmfd.
Grid—Filament	5.7 mmfd.
Plate—Filament	0.9 mmfd.

(2) R.F. Power Amplifier or Oscillator, Class C_2 Telegraphy—

D.C. Plate Voltage	1000v. max.
D.C. Grid Voltage	–200v. max.
D.C. Plate Current	100 ma. max.
D.C. Grid Current	35 ma. max.
Plate Input	100 w. max.
Plate Dissipation	30 w. max.





Typical Operation:

D.C. Plate Voltage	1000 volts
D.C. Grid Voltage—	
Fixed Supply	—75 volts
Or Grid Leak of	3000 ohms
Or Cathode Resistor of	600 ohms
Peak R.F. Grid Voltage	160 volts
D.C. Plate Current	100 ma.
D.C. Grid Current (approx.)	25 ma.
Driving Power (approx.)	3.8 watts
Power Output (approx.)	75 watts

---

(3) Plate Modulated R.F. Power Amplifier, Class C, Telegraphy, Maximum Modulation Percentage 100—

D.C. Plate Voltage	750v. max.
D.C. Grid Voltage	—200 max.
D.C. Plate Current	100 ma. max.
D.C. Grid Current	35 ma. max.
Plate Input	75 w. max.
Plate Dissipation	25 w. max.

Typical Operation:

D.C. Plate Voltage	750 volts
D.C. Grid Voltage—	
Fixed Supply	—60 volts
Or Grid Leak of	2000 ohms
Peak R.F. Grid Voltage	150 volts
D.C. Plate Current	100 ma.
D.C. Grid Current (approx.)	32 ma.
Driving Power (approx.)	4.3 watts
Power Output (carrier)	55 watts

(4) Audio Frequency Power Amplifier, Class B.—

Ratings, as in (2) except that D.C. grid voltage and current ratings do not apply.

Typical Operation:

D.C. Plate Voltage	1000 volts
D.C. Grid Voltage	—10 volts
Peak A.F. Grid-to-grid Voltage	156 volts
Zero-signal D.C. Plate Current	40 ma.
Max.-signal D.C. Plate Current	200 ma.
Load Resistance Plate-to-plate	11,600 ohms
Maximum Signal Driving Power	3.4 watts
Maximum Signal Power Output	145 watts

NEW PRODUCTS: LATEST RELEASES IN ELECTRONIC EQUIPMENT

HIGH-SENSITIVITY AVOMETER

A new high-sensitivity instrument has recently been developed by the Automatic Coil Winder and Electrical Equipment Coy., Ltd., and takes its place in the present well-known range of avometers as an instrument ideally suited to the radio technician.

In size and appearance the new high-sensitivity "Avo" is comparable with the standard models, its overall size being 8 in. x $7\frac{3}{8}$ in. x $4\frac{1}{2}$ in. deep. The scale length is 5 in., and an anti-parallax mirror is provided.

Ranges.—There are nine D.C. current ranges, giving full-scale readings from 50 microamps to 1000 milliamps. The millivolt drop does not exceed 500 mv. Seven D.C. voltage ranges are provided, with a sensitivity of 20,000 ohms per volt. The lowest gives a full-scale reading for 2.5 volts and the highest 2500 volts. A.C. voltage measurements are catered for by six ranges, the sensitivity being 1000 ohms per volt. Full-scale readings vary between 10 volts and 2500 volts.

Three resistance ranges—0-50 ohms, 0-50,000 ohms, and 0-5 megohms—are available by the use of an internal battery.

The instrument is tested according to B.S.89/1937 at a voltage of 6000v.

Accuracy.—D.C. current ranges are to B.S. limits, i.e., 1.2 per cent. of the indication from full scale to half scale; 0.6 per cent. of full-scale value below half-scale deflection. D.C. voltage ranges: 2 per cent. of the indication from full scale to half scale; 1 per cent. of full-scale value below half-scale deflection. A.C. voltage ranges to B.S. limits, i.e., 3.5 per cent. of the indication from full scale to half scale; 1.75 per cent. of full-scale value below half-scale deflection.

Resistance Ranges.—It is difficult to define the accuracy on resistance readings, but it may be taken as approximately plus or minus 3 per cent. of the reading at the centre of the scale.

A selector switch system, employing two switches, is used as on other models. The left-hand switch controls current and resistance ranges, while the voltage ranges up to 1000 volts appear on the right-hand switch. Electrical interlocking is provided between the two switches. Two additional terminals at the top of the instrument are used for the 2500 volts A.C. and D.C. measurements.

Owing to the industrial situation in England, these instruments will not be available in New Zealand for several months. Meantime, the National Electrical and Engineering Co., Ltd., will be pleased to furnish particulars to interested parties and to book orders against arrivals.

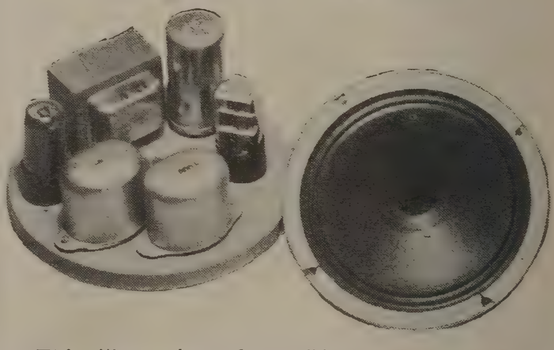
* * *

G-C MASTER DELUXE CABINET REPAIR KIT

A complete repair kit, put in a permanent metal box. All finishes supplied are spirit soluble and will not cut or damage surrounding finishes on cabinets, etc. Kit contains shellac sticks, alcohol lamp, French varnishes, rubbing felt and fluid, enamels, glue, steel wool, sandpaper, polish, directions, etc. Nothing else needed!

Available from
Swan Electric Co. Ltd., Wellington.

THE "AUTOCRAT" CAR-RADIO

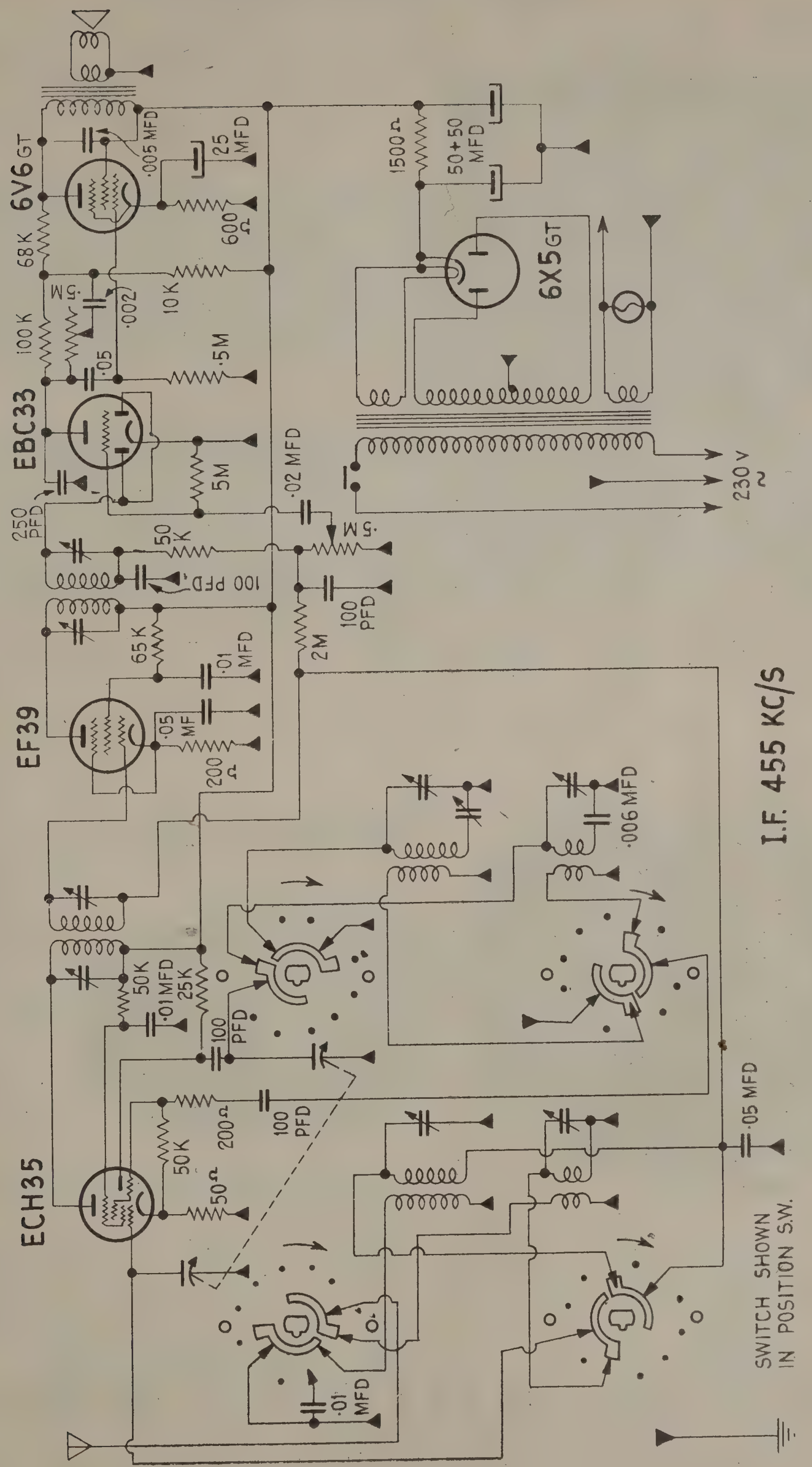


This illustration of the "Autocrat" car-radio has been submitted by the manufacturers, Messrs. Benson, Wills, and Walker, Auckland. It illustrates the unique mechanical design in that the power supply and output tube are assembled in the loud-speaker housing.

FOR THE SERVICEMAN

On the opposite page is the circuit of the Philips Radioplayer, Model 648. The alignment procedure for this receiver is standard in all respects.

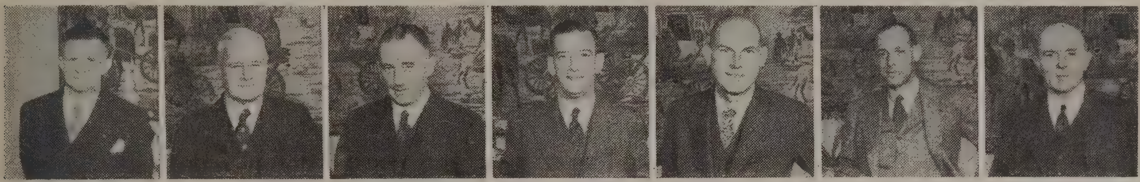
PHILIPS RADIOPLAYER—MODEL 648



OUR GOSSIP COLUMN

Following the Annual Meeting of the Radio Manufacturers' Federation, members of the R.M.F. entertained guests at a cocktail party and dinner at the Royal Oak Hotel, Wellington.

(Broadcasting Service), E. H. R. Green (P. & T. Department), I. K. McKay (National Commercial Broadcasting Service), D. I. McDonald (Manufacturers' Federation), R. E. Dawson (Secretary, R.M.F.), D. T. Clifton-Lewis, T. J. Spencer, Charles Hart, I. R. Cosgrove, J. M. Gifford, R. Slade, P. C. Collier, W. I. Cunninghame, S. C. Shea.



W. J. Blackwell — F. Johnson — L. Shiel — D. T. Clifton-Lewis — T. R. Clarkson — P. C. Collier — F. R. Callagan

W. I. Cunninghame — W. L. Harrison — Charles Hart — A. H. Buchanan — R. Slade — I. K. McKay — T. J. Spencer

Amongst those present were Messrs. W. J. Blackwell (President, R.M.F.), L. Shiel (Vice-president, R.M.F.), A. H. Buchanan (ex-P. & T., now W.A.R.B.), F. Johnston (Assistant Secretary, Department of Industries and Commerce), F. R. Callagan (D.S.I.R.), J. R. Smith and W. L. Harrison

In extending a very sincere welcome to the guests, most of whom were prominent Government officials, the President, Mr. W. J. Blackwell, thanked the representatives of the various Departments for the assistance and consideration shown in their dealings with the many problems confronting the radio indus-

try as a whole. With difficult times ahead, particularly with regard to the supply of raw and essential materials from overseas, the close co-operation given by the Government Departments has been, and will be, of untold value in the all important objective of keeping industry and commerce moving.

At the conclusion of dinner, members and their guests enjoyed the informal talks given by Messrs. F. Johnston, E. H. R. Green, F. R. Callagan and W. L. Harrison. On behalf of the R.M.F., the speakers were thanked by Messrs. D. T. Clifton-Lewis, P. C. Collier, W. I. Cunninghame and R. Slade.

Thus finished the first annual dinner of the R.M.F., when the President's statement that such an event should be repeated in the near future met with the hearty applause it deserved.

* * *

Goings on at National Carbon Pty. Ltd.

George McLennan, Factory Manager of National Carbon Pty. Ltd. left Wellington by the "Wahine" on Friday, November 7th, for a three weeks' visit to Sydney. Knowing George's ability to ferret things out, we have no doubt that alterations will be the thing of the day on his return. George joins the ranks of Tasman fliers on the return trip—happy landings, George!

R. D. Greenwood, Managing Director of National Carbon Pty. Ltd., left for Sydney in December. We would just hate to tell you how many times Ron has flown the Tasman. He is one of the regulars.

A recent visitor to Wellington was M. O'Sullivan, National Carbon's North Island Representative. Whilst here, Maurie was host to a number of "Eveready" dealers at the 10 o'clock and 3 o'clock "cup of tea" sessions. Like Aunt Daisy, this battery tea party business appears to have really cottoned on.

* * *

Mr. R. P. Nisbet

Philips Electrical Industries of New Zealand, Ltd., announce the appointment of Mr. Richard P. Nisbet as sales representative for Auckland province. The extension and strengthening of their distributing organization will be welcomed by Philips's nation - wide chain of retailers who market New Zealand-made Radioplayers as well as by the many retailers and users of all the other Philips products, of which perhaps the best known are the famous Philips lamps.

(Continued on page 54.)

THE BEGINNERS' SUPERHET

PART III—OPERATION

In Parts I and II of this article we described the principle and construction of the Beginners' Superhet. All that remains now is to say a little more about the operation of the set, and to tie this up with what we said in Part I about the superheterodyne principle.

The coils specified have covered two quite narrow portions of the short-wave spectrum, but this was done on purpose in order to make tuning a little easier, and because of the difficulties inherent in winding small coils for the broadcast band.

It will be remembered that our set consists of an oscillator, and a mixer or first detector, into which both the signals from the aerial and the output of the oscillator are fed. Further, because of the action of the first detector on the two frequencies at once, new frequencies appear in its plate circuit. The main ones are called sum and difference frequencies, because one is the **sum** of the oscillator and signal frequencies while the other is the **difference** between the two frequencies. The difference frequency is called the **intermediate** frequency, and is picked out from the other frequencies present by the I.F. transformer, which is connected in the plate circuit of the first detector or mix, V_1.

Thus, in order for a signal to be received, we have two circuits which must be tuned to **different** frequencies. First, the 1st detector grid circuit tuned by C_2 must be tuned to the frequency of the signal, and secondly, the oscillator must be tuned by means of C_9 to a frequency 465 kc/sec. higher than the signal. When this is done, the correct I.F. of 465 kc/sec. will be produced by the 1st detector and passed through the I.F. transformer to the 2nd detector, which acts on it in the usual way, giving the audio frequency output that feeds the amplifier and phones. Now if C_2 is tuned to accept the signal frequency, but C_9 is **not** tuned to the correct frequency, the signal will not be heard. Thus the tuning of the oscillator determines what signal, if any, will be heard. C_9 therefore controls the tuning of the set completely, and when a station is being searched for it is the adjustment of C_9 that causes the station to be tuned in and out, and the one next to it to be tuned out and in at the same time.

What we mean can be illustrated better by an example. Suppose that we have the set tuned to receive an amateur transmitting station on exactly 3600 kc/sec. The 1st detector input circuit will therefore be tuned to this frequency, and since the I.F. is 465 kc/sec., the oscillator is tuned to 4065 kc/sec. Now, suppose we wish to re-tune the set to receive another station which is on 3620 kc/sec. The question is: what will happen if (a) the oscillator tuning or (b) the 1st detector tuning is altered in an attempt to tune in the new station?

If the 1st detector tuning is adjusted **first**, all that happens is that the 3600 station to which we are listening gets weaker as C_2 is moved off the correct tuning point. In other words, it enables the signal from the first station to be tuned out, but does **not** bring in nearby stations.

Now, if the 1st detector condenser is readjusted for the 3600 kc/sec. station, and the oscillator condenser is adjusted instead, the original station is tuned out, but in addition, when it is tuned 20 kc/sec. higher than its original setting, the new station on 3620 kc/sec. will be heard. The set is still not properly tuned to the new station, because the 1st detector is still tuned to 3600 kc/sec. However, all that needs to be done to rectify this is to slightly adjust C_2 until the new signal is loudest. The set is now properly tuned to the new frequency.

This procedure should be tried, and what happens in practice will be found to correspond exactly to the above description.

GANGING

Now, although the oscillator controls the exact tuning of the set, no signals will be heard if the 1st detector circuit is detuned very far from the correct position for the particular setting of the oscillator. For this reason, namely, because there must be corresponding settings for both C_2 and C_9 if a signal is to be received, these condensers must be adjusted simultaneously if it is to be possible to tune in a signal at all settings of the oscillator condenser. In more advanced superhets., the circuits are so arranged that C_2 and C_9 form what is known as a **gang** condenser. That is to say, the two condensers are built as one unit, in such a way that turning a single shaft operates both condensers at once. When this is done, the tuned circuits are said to be **ganged.** When this is done, care has to be taken to see that the frequency of the oscillator is always 465 kc/sec. higher than that of the signal circuit. This is brought about by having an oscillator coil of a particular inductance compared with that of the signal circuit, and by using small trimming condensers in parallel with the sections of the gang condenser, and at the same time, a pre-set condenser known as a **padder,** which is placed in series with the oscillator coil.

All this complication is provided purely for the convenience of having single-dial control. There is no doubt at all that this convenience is worth the extra trouble involved in obtaining it, as evinced by the fact that all commercial superhets. use the system.

IMAGE RESPONSE

In Part I of this article we described how the 1st detector or mixer provides the intermediate frequency, which is the difference between signal and oscillator frequencies, the latter being the higher.

Now suppose, as before, that we have the receiver tuned to a signal on 3600 kc/sec. The oscillator frequency will be 4065 kc/sec., and the mixer grid circuit will be tuned to 3600 kc/sec. Unfortunately, no tuned circuit is perfectly selective, so that other signals in addition to the desired one will be passed from the aerial to the mixer grid. Suppose, for instance, that there happens to be a very strong signal present on a frequency of 4530 kc/sec. This signal is able to arrive at the mixer grid, somewhat weakened, because the signal tuned circuit is not selective enough to prevent it. The oscillator is tuned to 4065 kc/sec., so that the difference frequency of 465 kc/sec. will be produced by the mixer because that is the difference between the oscillator frequency and that of the unwanted 4530 kc/sec. signal. Thus, the 4530 kc/sec. signal will give a signal at I.F. **at the same time as the desired signal** of 3600 kc/sec. The I.F. transformer is therefore unable to distinguish between the wanted and unwanted signals, with the result that the latter causes bad interference with the former.

This type of interference is called **image** interference, and is one of the fundamental problems in the design of superhets. The obvious cure is to provide more selectivity ahead of the mixer grid, in which case the image signal on 4530 kc/sec. is so much reduced in strength when the input circuit is tuned to 3600, that the image signal cannot be heard.

With the present set, the existence of an image 930 kc/sec. higher than the proper signal frequency can be seen by setting the oscillator condenser at some convenient point, and then tuning carefully with C_2. It will be noted that **two** points on C_2 can be found at which signals or noise are received. The higher of these points is the image frequency. A very good demonstration of image response can be obtained by tuning in a **strong** signal with the oscillator after the 1st detector condenser has been set at the higher of the two frequencies where signals can be received. Now, C_2 is re-tuned to the lower of the two frequencies at which it peaks up. It will be noticed now that the signal is still present, but is considerably reduced in volume.

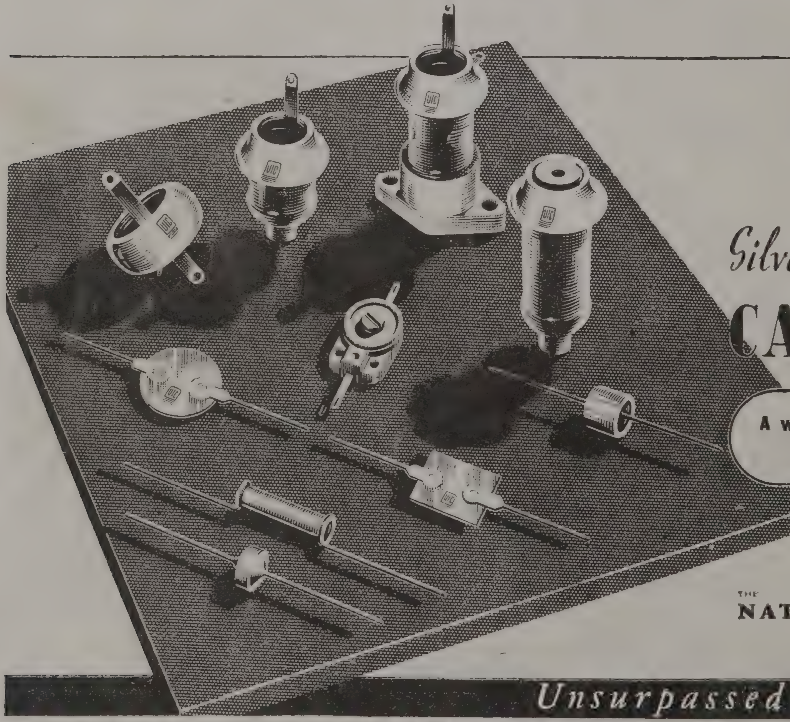
If these fundamental points about the superheterodyne are grasped through manipulation of this experimental set, then its construction will amply repay the trouble of building it, and the constructor will then be in a position to tackle successfully a more advanced superhet., either for broadcast or short-wave use.

GOSSIP COLUMN

(Continued from page 50.)

Mr. Nisbet, who saw service in the famous "mystery ships" in World War I, was awarded the Distinguished Service Cross and two bars, and, being on the reserve list, was immediately called up in World War II and appointed Extended Defence Officer, Naval Control Service Officer, and Staff Officer Operations. After seven and a half years' service, he has now been released and has already taken up his new duties with Philips.

Mr. Nisbet may be contacted on his Auckland phone, 60-466.



AMATEUR BAND RECEIVER

(Continued from page 6.)

this second conversion is the extreme stability and accuracy of the 2-3 mc. oscillator. This V-F-O is also linear, its frequency changing at a constant rate of 100 kcs. per shaft revolution, giving a range of 1 mc. for 10 turns.

PERMEABILITY TUNING

Moving iron cores have been used throughout the 75A thereby entirely eliminating the conventional tuning condenser. This is an obvious advantage, since the 75A circuit requires that six coils be tuned simultaneously. It also allows the use of an equal, linear frequency tuning range on all bands. Permeability tuning of the 2-3 mc. oscillator also results in greatly improved temperature and vibration stability, and gives the linearity which is one of the outstanding advantages of the 75A design.

SHUNT-BAND-SWITCHING

By shunt-band-switching is meant the use of separate tuning coils for each tuning range, in parallel with a permeability-tuned coil. A different condenser is also used with each separate coil to give correct frequency coverage. By the use of this system, 20 circuits are gang-tuned with only six iron cores. This neatly eases the mechanical problem and minimizes the number of space-wound coils required. It also allows the shunt coils and condensers to be separately trimmed, giving two-point tracking on all bands. A final but important advantage is that the impedance remains nearly constant on all bands. A good antenna match is thus obtained by a single antenna coil coupled to the first permeability-tuned coil.

MISCELLANEOUS FEATURES

The chassis for the 75A is mounted on a standard 19 in. panel, which makes it possible to remove the receiver from its cabinet and mount it on a standard rack if desired. The cabinet itself measures 21½ in. wide, 12¼ in. high, 13⅞ in. deep. The finish is standard black wrinkle and style strips are an attractive chromium plated steel. The over-all design is thus in harmony with the companion amateur equipments made by Collins.

A self-contained, well filtered power supply uses a 5Y3GT to provide all voltages for the receiver. Due to the extremely high stability of the receiver, voltage regulation is unnecessary. Even on CW signals extreme changes in supply voltage cause a change of only a few cycles in the note.

Furthermore, the CW note is independent of all except the tuning controls. Physical shock will not change the frequency unless it is violent enough to change the setting of the tuning controls.

The front panel controls are clearly indicated in the accompanying illustration and are felt to be self-explanatory. Additional controls for adjusting the sensitivity and zero level of the S-meter are found inside the cabinet. Note that the switch at the extreme right makes it possible to remove B+ from the plates without turning off the filaments.

The S-meter itself is conventionally calibrated from 1 to 9 in steps which represent approximately 6 db. of signal level. Additional steps above S-9 represent signal levels of 20, 40, and 60 db. above the usual scale.

A balanced or unbalanced antenna with an impedance up to 300 ohms may be connected to the 75-ohm input of the 75A. Sensitivity is such that a 1 microvolt signal will provide a satisfactory audio signal, with approximately a 10 db. signal-to-noise ratio. Image rejection is naturally high in the R.F. end of this receiver because of the high first intermediate frequency. Rejection by the radio frequency amplifier is 50 db., while rejection at intermediate frequencies is 70 db. At this point the fallacy of choosing a receiver by the number of R.F. stages should be pointed out. The above figures indicate very clearly that only one stage of R.F. is needed to give high image rejection when a high I.F. is used. Additional stages are thus unnecessary and unwarranted.

Two points about the crystal filter used are worth mentioning at this time. First is the fact that no loss of gain is caused by varying the bandwidth of the receiver; and secondly, detuning as a result of varying bandwidth is found to be negligible. Bandwidth, incidentally, is variable in 5 steps from 200 cycles to 4 kilocycles.

A.N.L. AND A.V.C.

The highly effective noise limiter is a series type clipper circuit embodying principles learned from extensive investigation of noise limiter circuits. The 75A noise limiter circuit automatically adjusts itself to different operating conditions.

Output is maintained with ±2 db. over a 2 microvolt to 1 volt input range. An amplified automatic volume control voltage derived at the third detector is applied to the R.F. and two I.F. stages, and to the second detector.

SUMMARY

The ham wants a receiver that fits his hand. No matter how many technical bugs have been ironed out, no matter how many tubes there are in the "box," if the dial doesn't practically tune itself across the hamband, it's no good. The 75A handles like a Colt Frontier model.

The ham wants a true single dial tuning receiver. You don't have true single dial tuning if you have to retune the main dial every time you touch one of the other knobs. Keeping a signal on some receivers is almost like playing an electric organ—it takes two hands and one foot to juggle the controls. Ease of tuning is the 75A's strong point.

Finally, the 75A is sensitive without being temperamental. Line voltage variations don't phase it and heavy trucks can rumble by all day without making it find you a new station.

These are the things Collins engineers have tried to design into the 75A, and it is felt that they have succeeded in doing this in a fashion hitherto not attained by any commercial receiver.

Frequency Coverage:

80 meters— 3.2- 4.2 mc. 15 metres—20.8-21.8 mc.
40 meters— 6.8- 7.8 mc. 11 metres—26.0-28.0 mc.
20 metres—14.0-15.0 mc. 10 metres—28.0-30.0 mc.

Image and I.F. Rejection:

Image rejection, 50 db.
I.F. rejection, 70 db.

Sensitivity:

One microvolt input provides normal audio output with 10 db. signal-to-noise ratio.

Selectivity:

Variable in five steps from 4 kc. to 200 cycles at 2x down. No loss of gain is caused by use of the crystal filter.

S-meter:

Calibrated from 1-9 in 6 db. steps and also shows 20, 40, 60 db. above S-9.

Audio output:

2.5 watts available at 500 ohms or 4 ohm terminals.

NOISE ON THE AIR

(Continued from page 32.)

in progress at any moment throughout the world. This means at least 100 flashes a second.

The time-table of this source of annoyance may be of interest. For frequencies between 1 and 5 megacycles per second (60 to 300 metres) the noise is far greater at night than during the day on account of reduced ionospheric absorption; for frequencies higher than this, there is little difference to be observed between the two periods. At sunset and sunrise, single and double peaks of noise level occur because of the rapid changes going on in the reflecting and absorbing characteristics of the ionosphere. In the northern hemisphere, the noise level is greater in summer than the winter since it is then that the source is nearest to us.

BEGINNERS' COURSE—PART 17

(Continued from page 35.)

but for those who build the set in the meantime the thing to remember is that for local stations C_3 can be backed off until the volume is just great enough with C_1 properly tuned in, and for distant stations the set is in its most sensitive condition just before C_3 gets to the position where a slight rushing sound is heard, indicating that the set is oscillating.

(To be continued.)

RADEL PORTABLE FIVE

(Continued from page 16.)

CONDENSER VALUES

In comparing this circuit with that of the "Portable Four" it will be noted that several condensers which in the latter set were given as 0.1 or 0.05 mfd. have been reduced in value to 0.02 mfd. This is because of space considerations in the present set, 0.02 mfd. condensers being physically much smaller than the larger values. Reducing the size in this way had no noticeable effect on the performance of the set and made it much easier to get all the required parts into the small space available.

QUESTIONS AND ANSWERS

(Continued from page 44.)

under various conditions to enable the operator to see whether an increase of overall gain is really necessary.

The other way that gain may be made up is at audio frequency. This is often quite a simple matter. For example, if a 6Q7 is used in the first audio stage, the substitution of a 6J7 pentode or 6B8 double-diode-pentode could provide quite substantial extra gain. Again, if room can be found on the chassis, an extra low-gain audio stage using a 6C5 or 6J5 may be added, as long as normal decoupling precautions are taken.

CLASSIFIED ADVERTISEMENTS

Rates are 3d. a word, with a minimum charge of 2/-. Advertisements must be to hand in this office not later than the fifteenth day of the month in order to be published in the issue appearing about the middle of the following month.

While all care will be taken, no responsibility can be accepted for errors. Advertisements should therefore be submitted either typed or printed in block letters.

FOR SALE: Signal Generator, Akrad, £12/10/-. Particulars from Miller's Radio Depot, Te Awamutu.

* * *

FOR SALE: Double push-pull Ferranti Audio Transformer A.F.5.C.C., 1 to 3.5. Apply MacLean, 4 Munro Street, Napier.

6L6 AMPLIFIER

(Continued from page 12.)

terminal strips where necessary. The amplifier is not a difficult one to build if the few points mentioned are given a due amount of care, and for its quality and power output it is a most inexpensive one that will easily repay a little time and thought put into its construction.

Printed in New Zealand by Harry H. Tombs Limited, 22 Wingfield Street, Wellington.

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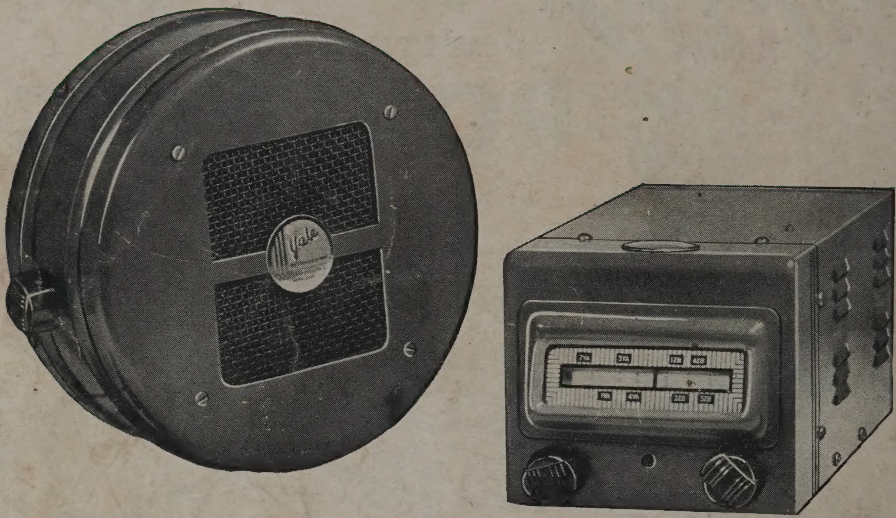

A new line of Auto Radio with grand new kind of long distance radio reception. Westco still leads with their now famous engineered Radio performance and have produced the value scoop of the year in Car Radio.

Outstanding style, tone and performance — yes. A smart-looking, top-quality, genuine 5-valve Heterodyne using latest valves, with synchronous vibrator which eliminates the rectifier and saves battery power. Highly sensitive, selective, really powerful, economical to run, and with famous Westco tone.
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Maunfacturers of Radio and Electronic Equipment — General Metal Workers. 12-14 Kitchener St., Auckland, Phones: 42-577, 49-012. Box 8, Wellesley St. Cable and Telegraphic Address: "WESTRAD," Auckland, N.Z.